Effect of moisture content and loading orientation on some strength properties relevant in the design of snake gourd (trichosanthescucumerina. l) seed handing device

Idowu D.O[1*] and Owolarafe O.K[2]

(1.Department of Agricultural Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria;
2. Department of Agricultural and Environmental Engineering, Obafemi AwolowoUniversity, Ile Ife, Osun State, Nigeria)

Abstract: The knowledge of mechanical properties under applied forces is very important to engineers during the design and handling of agricultural products. This study was carried out to evaluate the effect of moisture content and loading orientation on some strength properties of snake gourd (Trichosanthes cucumerina.L) seed. The strength properties measured are compressive extension at yield, compressive strain at yield, compressive load at yield, compressive load at break and energy at yield. These properties were evaluated at five moisture levels (6.3%, 8.6%, 12%, 14%, and 17% dry basis) under the three loading orientations (length, width and thickness). The results show that loading orientation has great effect on the compressive properties of the seed. At all moisture content of the seed considered, it was found that the width orientation had the highest compressive extension (32.5mm) and compressive strain at yield (1.3 mm/mm) while the thickness orientation had the highest measurement for compressive load at yield (73 N)and load at break (260 N)at 6.3 % (db) moisture content. The energy at yield was found to be highest at the length orientation (1.3 J) and lowest at the width orientation (0.16J) at 6.3 % (db) moisture content. The result of this experiment shows that as the moisture content is increasing the value of the compressive forces decreases. The result of this study will be very useful in the design of the seed washer, cleaner and decorticator.

Keywords: seed, compressive properties, moisture content, orientations, machine washer

Citation: Idowu D.O, and Owolarafe O.K. 2015. Effect of moisture content and loading orientation on some strength properties relevant in the design of snake gourd (trichosanthes cucumerina. l) seed handing device. Agric Eng Int: CIGR Journal, 17(4):337-345.

1 Introduction

Snake gourd also known as snake tomato *(Trichosanthes cuaimerina. L*) is a climbing herb with tendrils divided into three parts and stem growing to about 5 m. They are widely distributed all over the world with about 70 general and over 700 species (Robinson and Decker-Walters, 1997). The fruit is long with deep background (Figure 1). Most gourd specialist agrees that *Trichosanthes cucumerina and Trichosanthes auguring* are the same recommending, however, that the name *Trichosanthes auguring* be reserved for the wild species (Echo, 2006).

Figure 1 Snake gourd fruit

Snake gourd is grown principally in India for the immature fruit (that can be cooked and served as vegetable like Zucchini squash (a food delicacy eaten by the Indians).It can be used in curries or eat as vegetable

Received date: 2015-07-14 **Accepted date: 2015-09-11**

***Corresponding author: Idowu D.O.,** Department of Agricultural Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Email: idowu.david@yahoo.com.

like green beans (Grey-Wilson and Mathew, 1983). The bright red pulp around the matured seeds is extracted and used in cooking in much the same way that tomatoes are used (Enwere, 1998). It has been reported by Adebooye et al. (2005) that *T. cucumerina* seed (Figure 2) is a good source of nutrients and vitamins. Also the percentage of oil (34%) in the seed of snake gourd favourably compared with other oil seeds (Folarin and Enikanoselu, 2010). It has been reported that kernel washing before oil extraction also improve the oil content extraction to about 54 % (Idowu, 2015). There are several medicinal uses of this fruit viz: it helps to stimulate the production of body fluids, thus, relieving dryness; it can act as a natural antibiotic expectorant laxative and it has been shown to be excellent for diabetes. The leaves are used in indigenous medicine in India to treat jaundice, heart problems, fevers and alopecia.

Figure 2 Snake gourd seeds

Perhaps the most interesting news is that the new "AIDS" drug, compound "Q" is a refined protein called *Trichosanthin* which is derived from the '*Trichosanthes* (snake gourd) family. It has been shown that this protein has the ability to kill an “HIV” infected cell without affecting surrounding tissues (Shaw et al., 2005; Sha et al., 2013; Tropical data base, 2008). Compression of fibrous agricultural materials is experienced in processing operations such as cracking, shelling and oil pressing. The design of machines such as sheller, dehuller, harvester, etc. requires the knowledge of the force and pressure required to perform the desired operation. Compression properties have been found to depend on moisture content and orientation of the materials especially seeds Makanjuola (1972) evaluated the compression properties of melon seed as a function of moisture content and orientation of loading. Ramakrishna (1986) reported that the load required to open the hull of melon seeds varied along the edges and was minimal near the sharp tip. Teotia et al. (1986) reported reduction in hull breaking force as the moisture of pumpkin seed increased. Suthar and Das (1996) reported a differential force requirement for hull breaking of Karingda (*citrulluslanatus*) along different orientations. In addition they found that the cracking force of bambara groundnut decrease from 262 to 100N with increase in moisture content while deformation increased from 19 to 45 mm with increase in moisture content. There is little or no information on the compressive properties of snake gourd seed and these are necessary for the development of indigenous technologies for the processing of the crop. Therefore, the objective of this study is to determine the effect of moisture content on some compressive properties of the seed at different loading orientation.

2 Materials and methods

2.1Material collection

Snake gourd fruit were collected from the research farm of Agricultural Engineering Department of Ladoke Akintola University, Ogbomoso, Nigeria. The seeds were removed from the fruit and cleaned manually before storing for use in the experiments. It was ensured that the seeds were free of dirt, broken and immature ones and other foreign materials.

2.2 Moisture content determination

The moisture content of the seed was determined by using oven-drying method as adopted by Idowu and Owolarafe (2013) for the seed. A weighed sample of the seed was kept in an oven at a temperature of 105^{o}C for 6 h. The sample was weighed again at the end of the period to determine its final weight. This experiment was replicated five times and the average weight was recorded.

2.3 Moisture conditioning of the seed

The wetting techniques adopted by Shepherd and Bhardwaj (1986); Carman (1996); Deshpande et al. (1993); Aydin (2007) and Idowu and Owolarafe (2014) were used to vary the moisture content of the seed. Samples of the seed at desired moisture levels were prepared by adding calculated amounts of distilled water and sealing in separate polyethylene bags. Lower moisture content was achieved by oven-drying to the desired moisture. The samples were kept at low temperature (5^oC) in a refrigerator to equilibrate the samples and to avoid the growth of micro-organisms. Before starting a test, the required quantity of the sample was taken out of the refrigerator and allowed to warm up to room temperature. The final moisture content of the seed was then determined by oven-drying method.

2.4 Determination of compressive properties of snake gourd seed

The compressive properties were measured at five different moisture contents (6.3%, 8.6%, 12%, 14% and 17% dry basis).The three linear dimensions (Figure 3) were identified, that is, length (L), width (W) and thickness (T), hence, measurements of all the compressive properties were done on these orientations

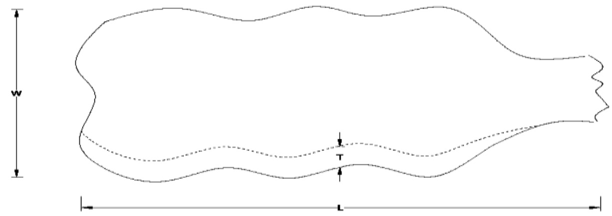

Figure 3 The three orientations of snake gourd seed (length (L), width (W), thickness (T))

Compressive test were conducted using a Universal Testing Machine (UTM) i.e. (Istron Electromechanical Testing Systems, Model 3369, 100kN, Istron corporation, USA). Seeds at different orientation (length, width and thickness) were loaded using the machine. The test result and graphs were automatically generated. Data obtained includes energy at yield, strain at yield, load at break, stress at yield and compressive extension at yield. For each of the moisture content, the experiment was replicated five times. The summary of the reading wereplotted inMicrosoft Excel 2007 and analyzed statistically using SPSS 13 software.

3 Results and discussions

The result of the experiment on the effect of moisture content and orientation on the compressive properties of snake gourd seed is as presented in Table 1.

Table 1 Effect of moisture content and seed orientation on the compressive properties of snake gourd seed

Compressive properties	Moisturecontents, % db.	Length, mm	Width, mm	Thickness, mm
	6.30	7.50±0.43	32.5±2.63	4.90 ±0.30
	8.90	4.70 ±0.32	29.0±3.33	4.70 ±0.25
Compressive extension at yield, mm	12.0	4.20 ±0.09	25.0±4.35	4.20 ±0.12
	14.0	3.80 ±0.67	23.5±3.22	3.80 ±0.32
	17.0	1.20 ±0.03	22.3±2.44	3.30 ±0.15
	6.30	51.0±2.02	60.0±4.30	73.0±3.22
	8.90	43.0±1.20	49.0±4.33	54.0±2.50
Compressive load at yield, N	12.0	20.0±1.06	43.0±5.32	50.0±2.30
	14.0	12.0±1.20	30.0±2.44	42.0±3.15
	17.0	8.0±0.62	28.0±3.01	20.0±1.05
	6.30	260.66±5.60	155.0±2.03	60.0±2.30
	8.90	2550.0±5.44	80.1±3.04	50.30 ±2.42
Compressive load at break, N	12.0	243.9±4.72	72.65±4.50	46.20 ±1.22
	14.0	235.0±5.35	63.41±3.62	40.40 ±2.30
	17.0	150.0±5.5	50.0±2.40	32.12 ±3.33
	6.30	1.1±0.01	0.2±0.02	0.16±0.01
	8.90	0.95±0.03	0.18±0.03	0.16±0.03
Compressive energy at yield, J	12.0	0.50±0.01	0.16±0.01	0.10 ±0.001
	14.0	0.44±0.02	0.09±0.01	0.09±0.001
	17.0	0.39±0.01	0.35±0.08	0.04 ±0.001
	6.30	1.1±0.01	1.35	1.20 ±0.03
	8.90	0.8±0.01	1.18±0.09	1.0±0.01
Compressive strain at yield, mm/mm	12.0	0.76±0.03	0.90±0.06	0.76±0.01
	14.0	0.65±0.04	0.81±0.06	0.48±0.001
	17.0	0.23±0.01	0.79±0.03	0.40±0.002

3.1 Effect of moisture content on compressive extension at yield of the seed

The compressive extension of the seed at the three orientations was found to reduce as the moisture content increased (Figure 4). The results show that the compressive extension is highly dependent on moisture content and also on seed orientation for the range of moisture content investigated (6.3% to17 % d.b). The results indicate that the compressive extension for width orientation was highest and varied from (32.5 to 22.3 mm) followed by length (7.5 to 1.2 mm) and thickness (4.9 to 3.3 mm) in the range of moisture content investigated. This implies that deformation is highest at width orientation of the seed and lowest in the length orientation. The result agrees with the earlier findings of Cecil and Watt (1997) for cowpea, Gezer et al. (2002) for apricot pit, Gubta and Das (1997) for sunflower seed, Altuntas and Yildiz (2007) and Konak et al. (2002) for chick pea seed. The deformation at higher moisture content might have resulted from the fact that the seed tended to be very brittle at high moisture content.

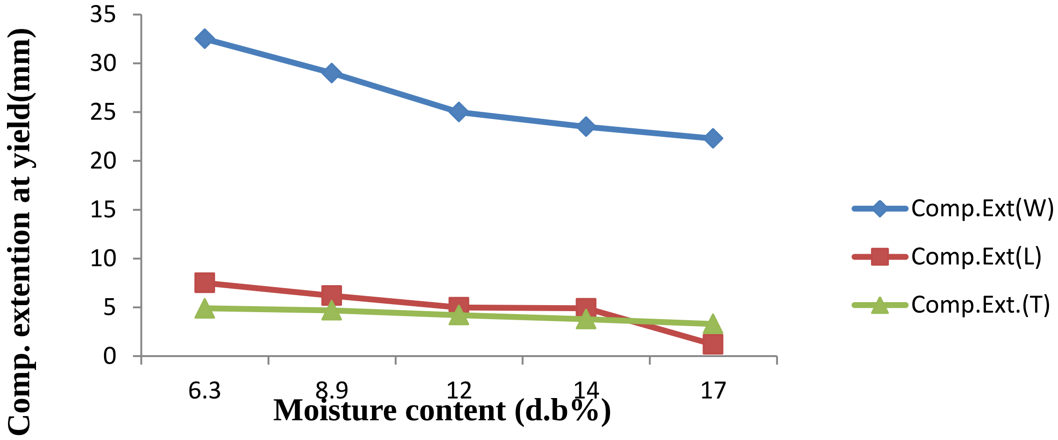

Figure 4 Effect of moisture content on compression extension at yield on length (L), width (W) and thickness (T) Orientation

The relationship between the compressive strain and moisture content of the snake gourd seed at different orientation can be represented by the correlation

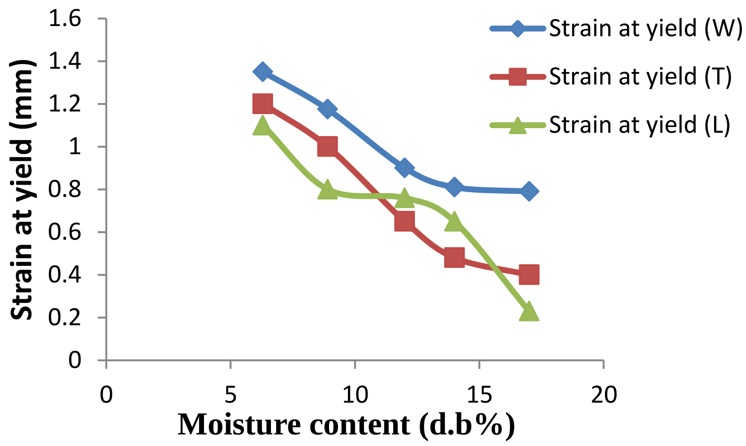

Figure 5 Effect of moisture content on strain at yield on length (L), width (W) and thickness (T) seed orientation

Equation (1), Equation (2) and Equation (3).

$$\varepsilon y_L \text{ (lenght)} = -0.2643mc^2 + 0.1957mc + 7.28 \quad (R^2 = 0.9172) \quad (1)$$

$$\varepsilon y_W. \text{ (width)} = -0.5071mc^2 - 5.6329mc + 37.78 \quad (R^2 = 0.9937) \quad (2)$$

$$\varepsilon y_T \text{ (thickness)} = -0.0357mc^2 - 0.1957mc + 5.16 \quad (R^2 = 0.9946) \quad (3)$$

Statistical analysis on the effect of moisture and seed orientation on the compressive strength was significant ($p > 0.05$).

3.2 Effect of variation of moisture content on compressive strain at yield

The deformation of the seed decreased as the moisture content increased from 6.3 to 17% db (Figure 5).As the moisture content increased from 6.8% to 17 % db the compressive strain at yield decreased from 1.1 to 0.23 mm/mm for length, 1.35 to 0.79 mm/mm for width and 1.2 to 0.4 mm/mm for thickness. This shows that the deformation was highest at length orientation and least for width orientation which implies that the seed is more flexible in the length orientation. The ratio of the size of seed under pressure is very important in deciding the screen size in the design of a Sheller or cleaner. The regression analysis indicates the relationship between moisture content and compressive strain can be represented as in Equation (4), Equation (5) and Equation (6).

$$Cs_{YL} = -0.0035m_c^2 + 0.0105m_c + 1.1135 \quad (R^2=0.9267) \quad (4)$$

$$Cs_{YW} = 0.0048m_c^2 - 0.167m_c + 2.2376 \quad (R^2= 0.984) \quad (5)$$

$$Cs_{YT} = 0.0046m_c^3 - 0.1739\ m_c^2 - 2.1649 \quad (R^2= 0.9846) \quad (6)$$

The results of the statistical analysis on the effect of moisture and seed orientation on the compressive strain were significant ($p< 0.05$).

3.3 Effect of moisture content on energy at yield (J)

The effect of moisture content and orientation of loading on energy at yield are presented in Figure 6. It could be observed that energy at yield depend on moisture content and orientation of the seeds. The energy at yield reduced from 1.1 to 0.39 J for length, 0.2 to 0.035 J for width, and 0.16 to 0.35 J for thickness orientation as the moisture content increase from 6.3% to 17.0 % db. This result shows that seed require more energy to rupture when compressed in the length orientation than in the other orientations. The result is in agreement with the report of Cecil and watts (1997) on cowpea. The mathematical relationship between the energy at yield and moisture content is as represented in Equation (7), Equation (8) and Equation (9) bellow.

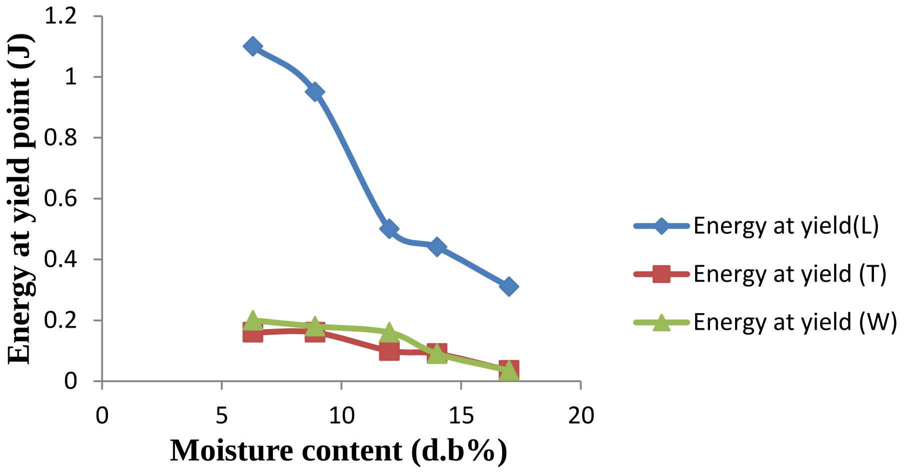

Figure 6 Effect of moisture content on energy at yield of seed on different seed orientation

$$Ey_{L}s = -0.005m_c + 0.210 \quad (R^2= 0.986) \quad (7)$$

$$Ey_{W}s = 1.36m_c^{-1.15} \quad (R^2= 0.925) \quad (8)$$

$$Ey_{T}s = 0.101m_c^{-0.824} \quad (R^2= 0.972) \quad (9)$$

The results of the analysis shows that effect of moisture content and seed orientation are significant at 0.05% level on energy at yield

3.4 Effect of variation of moisture content on compressive load at yield

Figure 7 shows how moisture content affects the compressive load at yield at different orientations. It could be observed that as the moisture content increased from 6.8 to 17 % db, the compressive load decreased from 73 to 20 N for thickness, 60 to 28 N for length and 51 to 8.0 N for width orientation. This shows that less force would be required to break the seed at higher moisture than at lower moisture. The reports are similar to those reported for various crops such as terbinth (Aydin and Ozcan, 2002) and almond nut (Aydin, 2003). The compressive force at length and width of the seed follows a gentle slope, while higher force is required when it is compressed along the thickness axis.

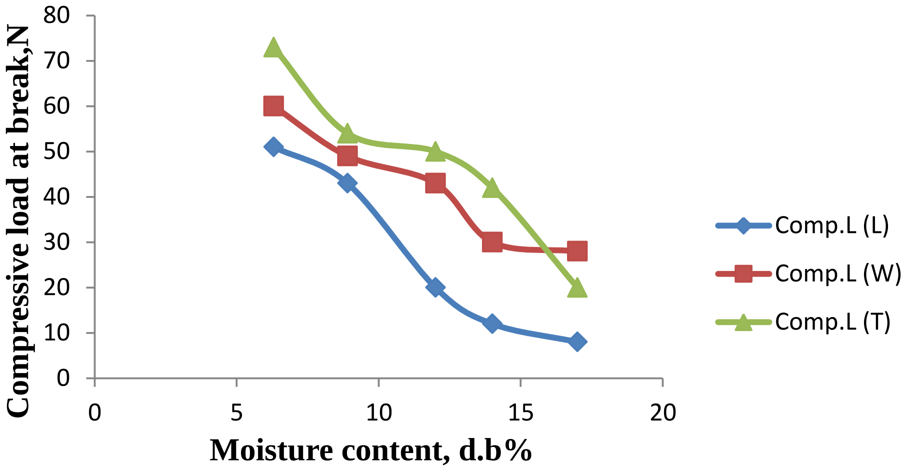

Figure 7 Effect of moisture content on compression load on length (L),width (W) and thickness (T) Orientation

The regression Equation (10), Equation (11) and Equation (12) on the effect of moisture content of the seed on the compressive load at different orientations are as shown below:

$$CFY_{L}s = 1.6429m_c^2 - 21.557m_c + 73.4 \quad (R^2 = 0.959) \qquad (10)$$

$$CFY_{W}s = 0.7857m_c^2 - 13.01m_c + 72.4 \quad (R^2 = 0.977) \qquad (11)$$

$$CFY_{T}s = -0.7143m_c^2 - 7.5143m_c + 78.2 \quad (R^2 = 0.943) \qquad (12)$$

The result of the statistical analysis on the effect of moisture content and seed orientation on the compressive load was found to be significant ($p > 0.05$).

3.5 Effect of variation of moisture content on compressive load at break

It could be observed from Figure 8 that as the moisture content increased the load at break reduced. The force required to break the seed under the length orientation decreased from (260 to 150.9 N), width (155 to 50 N) and thickness (60 to 32 N) as moisture content increased from 6.3 % to 17 % db. This may be because the increase in moisture content impaired the cellular matrix of the seed and consequently crack occurred at a lower level of compressive force.

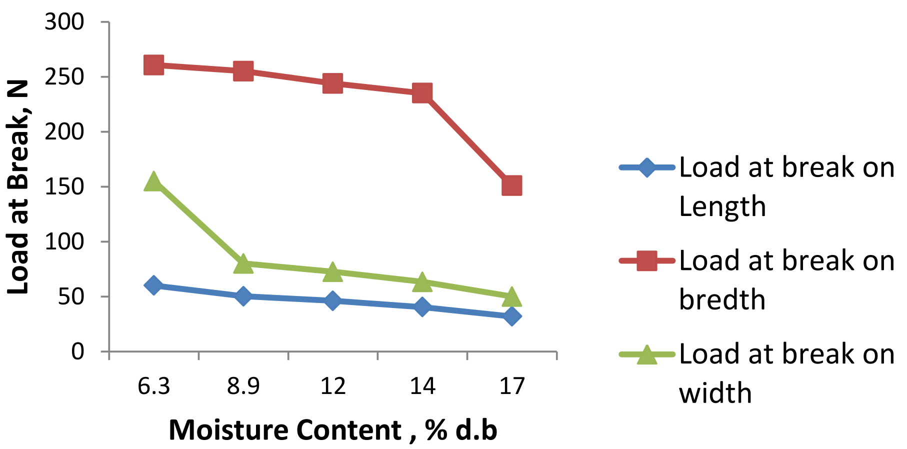

Figure 8 Effect of moisture content onLoad at break at different Orientation

The average load suddenly reduced immediately there is crack or fracture in seed. This is because there is less resistance by the whole seed. The results are similar to those reported by Liang et al. (1984) on macadamia nut kernel and Dursun (1997) for some crops. The mathematical relationship between the load at break and moisture content is as represented in Equation (13), Equation (14) and Equation (15) below.

$$LB_Ls = -0.833m_c^2 + 13.02\, m_c - 72.33 \quad (R^2 = 0.986) \qquad (13)$$

$$LB_Ws = -18.04m_c^2 + 123.3m_c - 295.4 \quad (R^2 = 0.944) \qquad (14)$$

$$LB_Ts = 8.822m_c^2 -.69.74m_c - 217.4 \quad (R^2 = 0.906) \qquad (15)$$

The result of the statistical analysis on the effect of moisture on the load at break shows that the effect was significant on the three orientations of the seed at 0.05 significant levels.

4 Conclusions

The effect of moisture content and loading orientation on compressive strength properties of snake gourd seed was carried out in this study. The following can be drawn out as conclusion from the study.

i) It is observed that the effect of moisture content is highly significant on compressive properties of snake gourd seed. The higher the moisture the lower the compressive properties.

ii) The loading orientations of the seed were also found to be very significant on the compressive properties of the seed.

iii) At lower moisture content, the snake gourd seed are tough and their fracture will be initiated by a high force irrespective of loading orientation of the seed.

iv) The force required to break the seed was found to be greater on the length orientation than on the other two orientations.

v) The effect of moisture content and loading orientation were found to be significant ($p<0.5$) on the compressive properties of snake gourd seed.

References

Adebooye, C.O,F. M. Oloyede, J. T.Opabode, O. O.Onagoruwa. 2005. Fruit characteristics and nutrient composition of Landrace Morphotypes of snake gourd. *Journal of vegetable Science.Oklahoma U.S.A*, 6(4): 1-6

Altuntas, E., and M.Yildiz.2007. Effect of moisture content on some physical and mechanical properties of faba bean (Viciafaba L,) grains. *Journal of Food Engineering*, 78(1): 174-183.

Aydin, C. 2007. Some engineering properties of peanut and kernel. *Journal of Food Engineering*, 79: 810 – 816

Aydin, C.2003. Physical properties of almond nut and kernel.*Journal of Food Engineering*, 60:315-320.

Ayin, C., and M.M.Ozcan.2002.Some Physico-mechanical properties of terebinthus (*Pistacia terebinthurs L*) fruits.*Journal of Food Engineering*, 53:97-101.

Carman, K. 1996. Some physical properties of lentil seeds. *Journal of Agricultural Engineering Research*, 63: 87-92

Cecil, A.W., and K.C.Watts.1997. Properties of cowpea (var. Minica Beans). *Journal of Agricultural Engineering Research*, 68:159 – 167.

Desphande, S.D., S. Bal, and T.P. Ojha. 1993. Physical properties of soybean. *Journal of Agricultural Engineering Research*., 56: 89 – 98.

Dursun, I.G. 1997. Determination of the shelling resistance of some products under the point load. In National symposium on mechanization in Agriculture, 950 – 957, Turkey: Tokat.

ECHO.2006. Snake Gourd. ESCHO Plant Information Sheet USA http//www.echonet.org. (Accessed 2nd may ,2010)

Enwere, N. J. 1998.*Foods of Plant Origin*. Afroorbis Publication, Nsukka, Pg. 153-168Faruk,O.,and V. kubilay.2004. Some physical mechanical and aerodynamic properties of pine (pinuspinea) nuts. *Journal of Food Engineering*, 86: 191 -1196.

Folarin, O.M.,O.N.Enikanoselu. 2010. Evaluation of the effect of temperature on the stability of metal soaps of *Trichosanthes cucumerina* seed oil. *Journal of Science Environment Management*, 14(3): 69-73.

Grey- Wilson, andV. Mathew.1983.Gardening on Walls.ISBN-00-2192206.

Gezer, I., H.Haciseferogullari, andF.Demir. 2002. Some physical properties of Hacihalilogu apricot pit and its kernel.Physical properties of Hacihalilogu apricot pit and its kernel.*Jounal of food Engineering*, 56:49-57.

Gupta, R. K., and S. K.Das.1997. Physical properties of sun flower seeds.*Journal of Agricultural Engineering Research*, 66: 1-8.

Idowu, D.O., and O.K.Owolarafe.2013. A study of hydro-aerodynamic properties of snake gourd (*trichosanthes cucumerinas l.*) seed, kernel and chaff. *Journal of Agricultural Technology*, 9(7): 1691-1701.

Idowu, D.O., and O.K.Owolarafe. 2014. Physica properties of snake gourd seed (*Trichhosantes Cucumerinal L.*) Relevant in grading and separation. *Agric. Eng. Int. CIGR. Journal.,*16(1): 304-312.

Idowu, D. O. 2015.A study on the effect of washing of kernel on yield, colour and a rheological property of snake gourd oil.*Journal of Agricultural Technology*,11(4): 811-822..

Konak, M ,K. Carman and C, Ayadin. 2002.Physical properties of chickpears seeds. Biosystem Engineering 82(1):73-78

Liang, T., L.Chin,and J.B.Mitchell.1984. Modeling moisture influence on macadamia nut kernel recovery. *Transaction – ASAE*, 27: 1538 – 1541.

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

Ramakrishna, P. 1986. Melon seeds-evaluation of the physical characteristics. *Journal of Food Science and Technology,* 23: 158 – 160.

Robinson and Decker-Walters.1997. Cucurbits CAB International, New York Pg. 156

Shepherd, H., and R.J.Bhardwaj.1986. Moisture dependent physical properties of pigeon pea. *Journal of Agricultural Engineering Research*, 35: 227 – 234.

Shaw, P.C.,K.W.Lee, and K.B.Wong.2005. Recent advances in tricosanthes, a ribosome- inactivating protein with multiple pharmacological properties. *Toxicon*, 45(6): 683- 689.

Sha, O.A.,N.I.U.Junferi, N.G.Tzi-Bung, Y.U.Eric,C.N.O.Paang, F.U.Xiaoyuan,and J.Wengi. 2013. Anti-tumor action of trichosanthin, a type 1 ribosome- inactivating protein, employed in traditional Chinese medicine.*A mini review*, 71(6): 1387-1393.

Suthar, S. H., and S. K.Das.1996. Some physical properties of *karinge* seeds. *Journal of Agricultural Engineering Research*,65*:*15-22.

Teotia, M.S., P.Ramakrishama, S.K.Berry, and S.Kuar.1986. Some engineering properties of pumpkin seeds. *Journal of Food Engineering*, 9: 153 – 162.

Tropical data base. 2008. Internet update on snake Gourd. Available at http/www./google.com (accessed 2nd may, 2010).