



# World Scientific News

An International Scientific Journal

WSN 97 (2018) 125-138

EISSN 2392-2192

---

---

## Some Engineering Properties and Natural Durability of Avocado (*Persea americana* Mill.) Pulp and Seed

**K. Nwaokobia<sup>1,\*</sup>, O. H. Oghomwen<sup>2</sup> and P. O. Omoregie<sup>3</sup>**

<sup>1</sup>Department of Agricultural and Bio-Environmental Engineering Technology,  
Federal Polytechnic, P.M.B 13, Auchi, Edo State, Nigeria

<sup>2</sup>Department of Plant Biology and Biotechnology, Faculty of Life Science, University of Benin,  
P.M.B 1154, Benin City, Nigeria

<sup>3</sup>Department of Biochemistry and Molecular Biology, Federal University Birnin Kebbi,  
P.M.B 1157 Birnin Kebbi, Kebbi State, Nigeria

\*E-mail address: [nwaokobia.kingsley@gmail.com](mailto:nwaokobia.kingsley@gmail.com)

Tel: +234-8066755184

### ABSTRACT

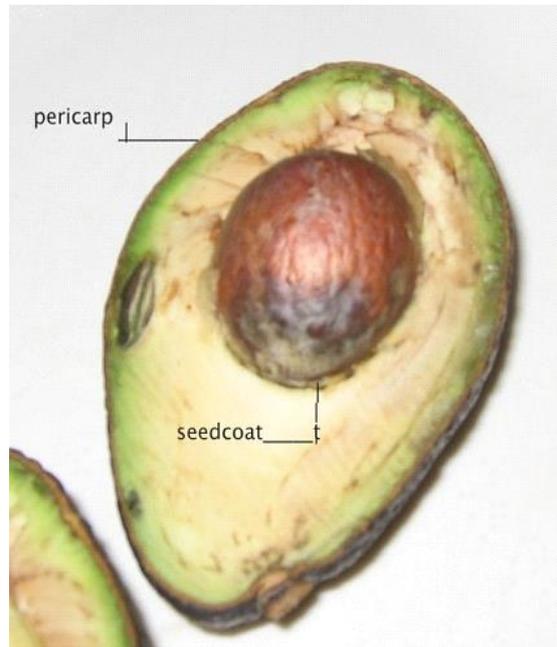
An investigation on Some Engineering Properties and natural durability of Avocado (*Persea americana* Mill.) pulp and seed were carried out in different locations. Avocado fruit is a tropical fruit and is one of the most productive plants per unit of cultivated area. Avocado stands out for its high nourishing value and it is usefulness to growth and development. It has also been the subject of intense and varied use in the past not only for its importance in food but also for medicinal needs. From the investigation carried out on mechanical properties, avocado seed will attain a value of 2352.200N force at peak and any value higher than this; will cause it to break when determining the effect of moisture content on avocado seed along longitudinal loading. In the same vein, avocado seed will attain a value of 1497.000N force at peak and any value higher than this; will cause it to break when determining the effect of moisture content on avocado seed along axial loading. The thermal properties investigated were thermal conductivity, thermal diffusivity, ash, specific heat and calorific value. This research work and results obtained will enable engineer in designing machines that can be used for processing, handling and storage of avocado pulp and seed.

**Keywords:** Avocado, *Persea americana*, storage of avocado pulp and seed, mechanical properties

**1. INTRODUCTION**



**Fig. 1.** Avocado fresh fruit



**Fig. 2.** Cross section of Avocado pulp and seed showing the pericarp and seed coat



**Fig. 3.** Cross section of Avocado pulp



**Fig. 4.** After de-skinning and de-stoning

Avocado (*Persea americana*) is a tree native to Mexico and Central America classified into the flowering plant family Lauraceae along with Cinnamon, Camphor and Bay Laurel [1]. Avocado which has common names like Alligator pear, Ahuacate and Avocato refers to fruit botanically a large berry that contains a single seed. It grows as a large tree to height of 15 m – 17 m. It bears a large fleshy fruit that is oval or spherical in shape, the skin of the fruit can be thick and woody although the plant is native to tropical America (Mexico and Central America), and numerous varieties are now widely distributed throughout the world.

It is one of the most productive plants per unit of cultivated area since it is a tropical fruit. Avocado stands out for its high nutritional value and it is beneficial to growth and development. It has also been the subject of intense and varied use during the past not only for food but also for medicinal purposes. The American Indians have used the seeds to treat dysentery and diarrhea [2].

The engineering properties of a biomaterial may be regarded as those properties which control the behavior of the material under condition of externally applied load (Ibarz, 2005). Knowledge of these properties is essential for rational design of storage and handling equipment. Most processed foods and agricultural materials receive some type of heating or cooling during handling or manufacturing [3].

Design and operation of processes involving heat transfer requires special attention due to the heat sensitivity of foods. Both theoretical and empirical relationships used when designing or operating heat processes, requires knowledge of the engineering properties of the foods under consideration. Improved methods of handling and processing the seed and pulp of Avocado using suitable machines and equipment can be developed and improved upon if the Engineering properties are known [4].

It is significant to investigate the Engineering properties of biological agricultural material because it will aid the Engineer, Food scientist and processor towards the efficient processing, handling and equipment development. This study was carried out to investigate some engineering properties of avocado pulp and seed.

Despite the benefits and usefulness of avocado fruits, pulp and seed to the human existence, its seeds have also been found to possess insecticidal, fungicidal and anti-microbial activities. Proper investigation on the engineering properties of avocado pulp and seed will help reduce or eradicate its effect and harm thereby increasing its usefulness to man, health and energy [5-16].

## **2. MATERIALS AND METHODS**

Samples of avocado fruits used for this analysis were obtained from Uchi Market in Auchi, Estako West Local Government Area of Edo State, Nigeria. The fruits were thoroughly screened to remove the bad ones.

### **Determination of mechanical properties of avocado seed.**

The mechanical properties of avocado pulp and seed were determined at National Centre for Agricultural Mechanization (NCAM) KM 20 Ilorin-Lokoja expressway Idofian, Kwara State.

### **Determination of Compressive Test**

This refers to the capacity of the material to withstand load. Some materials fracture at their compressive strength limits; while others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive test can be measured by plotting applied force against deformation in a testing machine.

### **Sample preparation**

Each of fresh fruit (avocado pulp and seed) was sourced, sorted, cleaned and made ready for mechanical testing. Selected seeds were sourced, sorted, cleaned and were subject to conditioning. In conditioning these seeds, they were sorted in group of two and three depending on availability due to the fact that some are already almost out of season. Each group was labeled accordingly.

### **Determination of moisture content before oven drying**

Moisture cans were cleaned and labeled according to the number and group of each selected biomass material. Each moisture can be weighed and recorded according to samples and grouping, then samples were placed in each moisture can accordingly and were weighed together, an initial mass of moist or wet sample with can in grams was recorded. First group were to be mechanically tested as wet sample as received after which they were to be immediately prepared for moisture content determination following the same procedure above. With proper record of empty can and can with sample mass been taken, they were all placed in a laboratory oven set to 105 °C. Second and third group were to be pre-dried at 105 °C for 2hrs and 4hrs respectively in order to investigate effect of moisture content variation on the mechanical properties of the samples. After 2hrs of pre-drying, second group were removed from the oven, placed in desiccators containing desiccant, allowed to cool down, and then weighed and return back into the desiccator containing desiccant awaiting mechanical testing. The same was done on the third group after 4hrs.

### **Moisture Content Determination**

This test was performed to determine and vary the water (moisture) content of some selected biomass materials. The moisture content is the ratio, expressed as a percentage, of the mass of “pore” or “free” water in a given mass of material to the mass of the dry material solids [11].

### **Determination of Thermal Properties of avocado pulp and seed**

The following Thermal properties of avocado pulp and seed were determined using different equipment (machine) and at different location. The various properties analyzed were;

- Thermal conductivity
- Thermal diffusivity
- Ash content
- Calorific value
- Specific heat

The analysis was carried out in the laboratory of Physical Properties and Quality Evaluation, Imo State University of Technology, Owerri, Imo state, Nigeria.

### **Preparing the Sample for thermal properties determination**

The seed moisture content was determined by drying it in the oven at 104 °C for over 24hrs. were obtained by spraying pre-determined amount of distilled water on the seed followed by periodic tumbling of the samples in a sealed container. The samples were then stored at 5 °C to evenly distribute the moisture before analyzing.

### **Determination of Specific Heat ( $C_p$ )**

This is the amount of heat needed to raise the temperature of unit mass by unit degree at a given temperature. The SI units for  $C_p$  are therefore ( $\text{kJ Kg}^{-1} \text{K}^{-1}$ ) [11]. The tests were carried out in triplicate, In brief, a single avocado, weighed to 100 mg, was hermetically sealed in a 40 ml standard aluminum crucible, and loaded in the DSC30 cell of a TC10 thermal analyzer, MettlerTA3000 system (Mettler Instrumente AG, Switzerland). The specific heat measurements were made between 5 and 20 °C temperature at a heating rate of  $5 \text{ K/min}^{-1}$  against a pre-recorded blank compensation curve (the baseline when an aluminum crucible contained no sample).



**Fig. 5.** DSC30 cell of a TC10 thermal analyzer.

### **Thermal conductivity ( $k$ )**

This represents the quantity of heat  $Q$  that flows per unit time through a food of unit thickness and unit area having unit temperature difference between faces; SI units for  $k$  are [ $\text{W m}^{-1} \text{K}^{-1}$ ]. In this study, Quick Thermal Conductivity Meter (QTM-500) was used to determine the thermal conductivity of sample.



**Fig. 6.** Quick Thermal Conductivity Meter (QTM-500)

### **Determination of thermal diffusivity**

Thermal diffusivity determines the speed of heat of three-dimensional propagation or diffusion through the material. It is represented by the rate at which temperature changes in a certain volume of food material, while transient heat is conducted through it in a certain direction in or out of the material (depending if the operation involves heating or cooling). Thermal conductivity, thermal diffusivity and specific heat capacity each can be measured by well-established methods, but measuring any two of them would lead to the third through the relationship

$$\alpha = \frac{k}{\rho C_p}$$

where:  $\alpha$  is the thermal diffusivity,  $k$  is the thermal conductivity,  $\rho$  is the bulk density and  $C_p$  is the specific heat. The equation shows that  $\alpha$  is directly proportional to the thermal conductivity at a given density and specific heat. Physically, it relates the ability of the material to conduct heat to its ability to store heat.

Using the equation  $\alpha = \frac{k}{\rho C_p}$

### **Determination of Ash**

It is the weight of residue obtained after burning a weighed quantity of a given sample in an open crucible i.e in the presence of air at 750 °C in a muffle furnace till a content weight is achieved.

$$\text{Ash in a sample} = \frac{\text{Weight of residue ash obtained}}{\text{Weight of sample initially taken}} \times 100\%$$

### **Determination of Calorific Value**

Calorific value is defined as the quantity of heat liberated by the combustion of unit quantity of fuel.

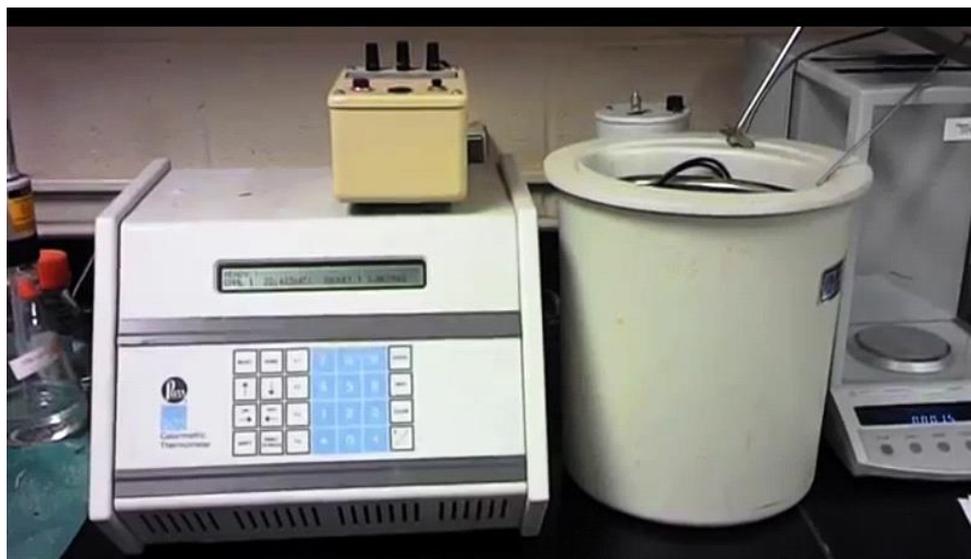
### **Principle of calorific value determination**

When a weighed quantity of fuel is burnt in the calorimeter, the heat liberated is used up in heating the calorimeter and the water in the calorimeter. By equating the heat given out by the fuel with heat taken up by the calorimeter and water, the calorific value as known as the energy value is determined. In this study, the Bomb Calorimeter was used to determine the calorific value of the various samples in accordance with the ASTM Standard D-2015 technique.

### **Determination of calorific value using a bomb calorimeter.**

Bomb calorimeter is used for determining the calorific value of solid and liquid fuels. Bomb calorimeter consists of a strong stainless steel vessel, called BOMB, capable of withstanding high pressures. The bomb is provided with a lid which can be screwed firmly on the bomb. The lid in turn is provided with two electrodes and an oxygen inlet valve. One of the electrodes is provided with a ring to accommodate the Silica crucible.

The bomb is placed in a copper calorimeter having a known weight of water. The copper calorimeter, in turn, is surrounded by an air jacket and water jacket to prevent loss of heat due to radiation. The calorimeter is provided with an electrical steamer for steaming water and a Beckmann thermometer.



**Fig. 7.** Bomb calorimeter

### 3. RESULTS AND DISCUSSION

#### Results on thermal properties of avocado pulp and seed

The following results on different thermal properties of avocado pulp and seed were obtained in the experiment carried out in the Imo State University of Technology laboratory, Owerri.

**Table 1.** Results of thermal conductivity (w/m-k) of avocado pulp.

Biomass	Replication	Temp (°C)	M.C (%) by mass	Thermal conductivity (w/m-k)
Avocado pulp	1	37	82.3	0.412
	2	37	82.1	0.409
	3	37	82	0.415
Average		37	82.1	0.412

**Table 2.** Results of thermal conductivity (w/m-k) of avocado seed.

Biomass	Replica	Temp (°C)	M.C (%) by mass	Thermal conductivity (w/m-k)
	1	35	55	0.595
	2	35	55	0.518
	3	35	53	0.590
Average		35	54.3	0.589

**Table 3.** Specific heat results obtained on avocado pulp and seed ( $\text{kJ}^{-1}\text{kg}\cdot\text{k}^{-1}$ )

1st	0.72	0.84	1.13	1.31	1.70
2nd	0.70	0.81	1.14	1.33	1.71
3rd	0.69	0.82	1.15	1.32	1.72
Average	0.70	0.82	1.14	1.32	1.71

**Table 4.** Ash content results obtained on avocado pulp and seed

Biomass	Actual weight taken for Ash (g)			Weight of ash obtained (g)			Average weight of Ash obtained (g)	Ash content %
	1	2	3	1	2	3		
Pulp	100	110	105	0.925	0.940	0.921	0.929	0.885
Seed	90	85	92	0.451	0.392	0.463	0.435	0.563

**Results on mechanical properties of avocado pulp and seed**

The following results on different mechanical properties of avocado pulp and seed were obtained in the experiment carried out in National Centre for Agricultural Mechanization (NCAM), KM 20 Ilorin-Lokoja expressway Idofian, Kwara State.

**Table 5.** Results of moisture effect along longitudinal loading on avocado seed

Avocado seed								
Compare moisture effect along longitudinal loading								
Drying Time @ 105 °C	Height (mm)	Force @ Peak (N)	Def. @ Peak (mm)	Strain @ Peak (%)	Force @ Yield (N)	Def. @ Yield (mm)	Strain @ Yield (%)	Energy to Peak (N.m)
0 time	48.24	2352.200	18.812	1106.588	513.800	4.097	241	21.282
2 hrs	40.35	569.800	17.915	1053.824	180.240	4.657	273.941	4.477
4 hrs	36.56	321.000	17.240	1014.118	162.680	10.767	633.253	2.273

**Table 6.** Result of moisture effect along axial loading on avocado seed.

Avocado seed								
Compare moisture effect along axial loading								
Test No	Height (mm)	Force @ Peak (N)	Def. @ Peak (mm)	Strain @ Peak (%)	Force @ Yield (N)	Def. @ Yield (mm)	Strain @ Yield (%)	Energy to Peak (N.m)
0 time	44.420	1497.000	16.315	959.706	671.400	8.475	498.529	10.875
2 hrs drying	41.430	427.490	16.802	988.353	195.520	6.954	409.059	3.210
4 hrs drying	37.210	81.680	8.754	514.941	39.830	4.046	238.000	0.352

#### 4. DISCUSSION

Discussion of the results obtained in moisture content determination along the longitudinal and axial loading on avocado seed

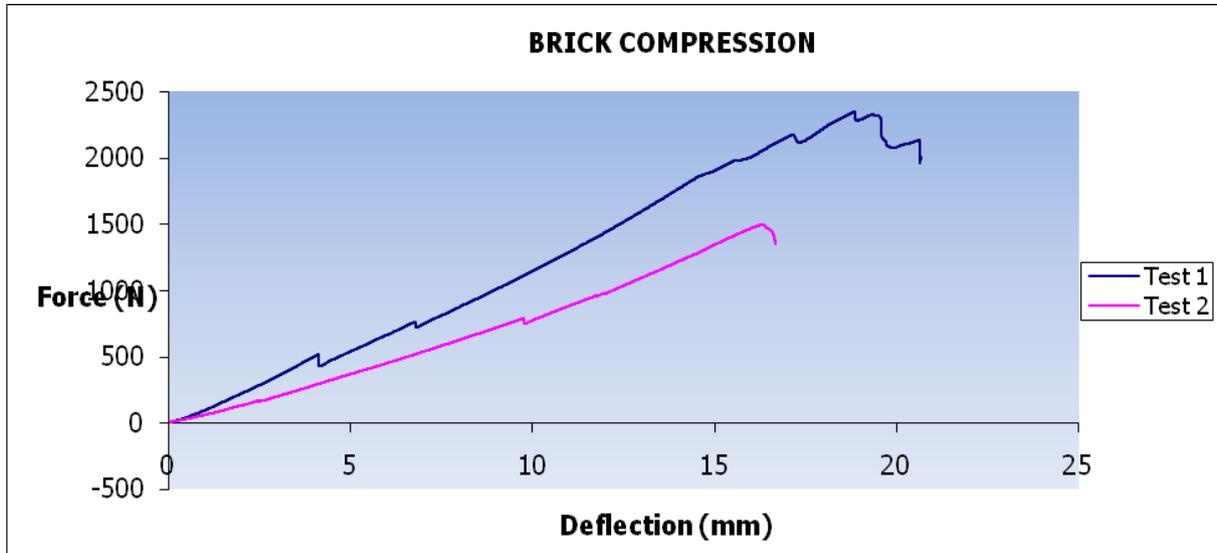


Fig. 8. Graphical representation of force (N) against deflection (mm) on avocado seed in 0-time oven dry

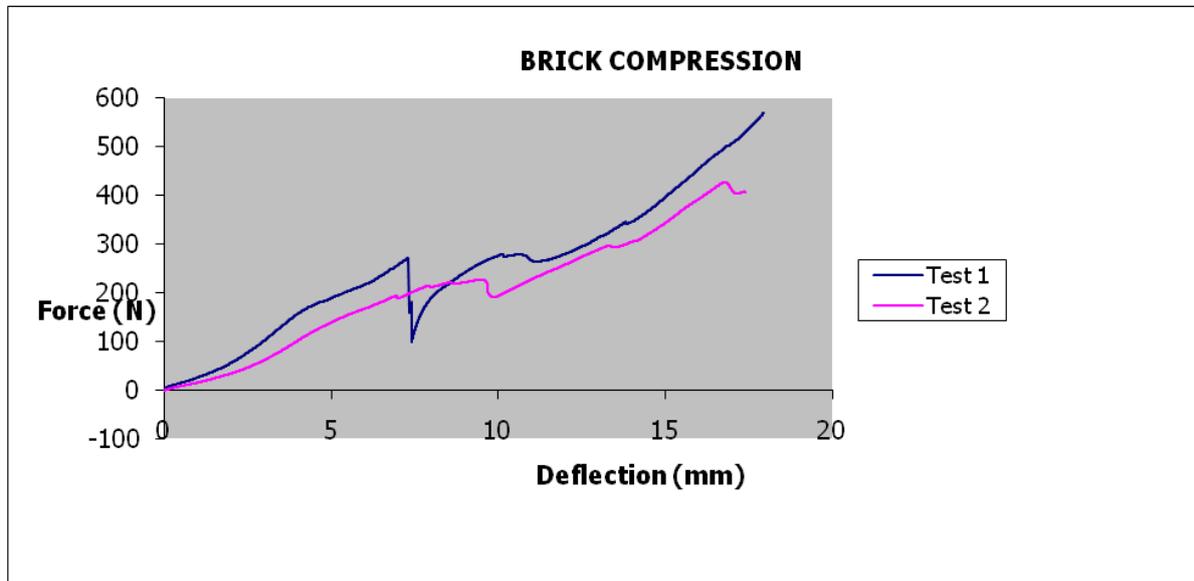
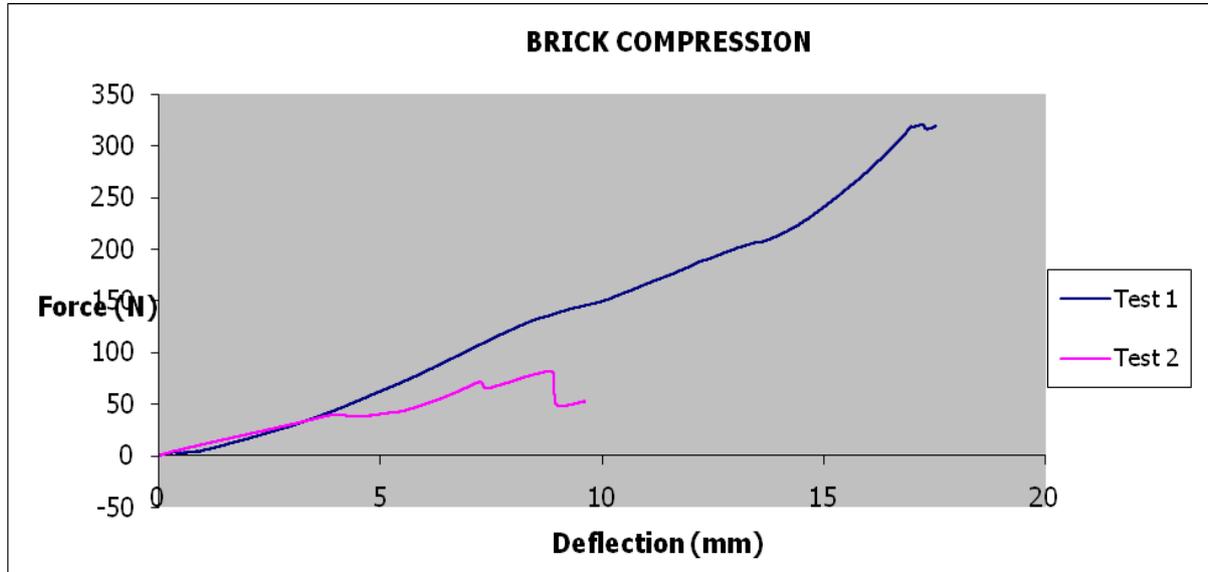


Fig. 9. Graphical representation of force (N) against deflection (mm) on avocado seed in 2hrs-time oven dry



**Fig. 10.** Graphical representation of force (N) against deflection (mm) on avocado seed in 4hrs-time oven dry

The result shows that there is shrinkage with moisture loss from Height column, force and energy required to rupture the seed reducing with reduction in moisture content. On the longitudinal loading, though force required to compress the seed reduces with moisture reduction yet deflection at yield shows that it become elastic up till yield point as it loses moisture then becomes brittle to failure as indicated on deflection @ peak column. Result also shows that force require to rupture Avocado seed is higher when crushing along the cleavage than perpendicular to cleavage. This is possibly due to the fact that the cleavage opens up at a stage of crushing and behave elastically at all moisture of mechanical testing yet at reducing degree with moisture reduction.

Below is a graphical representation of the effect of moisture content on avocado seed along longitudinal and axial loading as force measured in Newton (N) against deflection measured in Millimeter (mm) for zero time, two hours and four hours respectively. Test one which is having a blue line, represent effect of moisture content along longitudinal loading while Test two which is having a pink line, represent the effect of moisture content along axial loading.

**Definition of Terms in calculations**

- Load@Peak: Maximum force reached during test (N)
- Deflection@Peak: Distance travelled from initiation of test to point at which force reaches maximum (mm).
- Strain@Peak: Strain at which maximum force is reached (strain=distance travelled divided by sample height in %)
- Energy@Peak: Work done to point at which maximum force is reached (Energy=force/deflection curve) unit: g-cm, or Ib.in

Load@Yield:	Force at point of yield. (Yield = point at which initial straight line portion of load/deflection curve dips, i.e. drop off in load measured in N)
Deflection@Yield:	Distance travelled at point of yield (mm)
Strain@Yield:	Strain reached at point of yield (%)
Energy@Yield:	Work done to point of yield (g.cm, or Ib.in)
Load@Break:	Force at which maximum deflection is reached (N)
Deflection@Break:	Maximum deflection (mm).
Strain@Break:	Strain at point of maximum deflection (%)
Energy@Break:	Energy at point of maximum (g·cm)

### **Discussion of results obtained in determining different thermal properties of avocado pulp and seed**

The variation of some thermal properties of avocado pulp and seed are presented in table one, two and three which are determination of thermal conductivity, specific heat and ash content respectively. From the results obtained in the thermal conductivity test carried out on avocado pulp and seed (i.e Table 1), it was shown that there was variation in moisture content by mass as the temperature remained constant in the three replicates.

In the specific heat test (Table 2) carried out on avocado pulp and seed, the result showed that there's variation in the results obtained for temperature between 1-15 °C and temperature between 15-30 °C. Table 3 shows the determination of ash content on avocado pulp and seed and the results obtained.

## **5. CONCLUSION AND RECOMMENDATION**

### **Conclusion**

From the experiment carried out on mechanical properties and results obtained, mechanical test shows that moisture content plays an important role in determining mechanical properties of avocado pulp and seed.

The nutritional value of avocado fruit makes it a good raw material for cosmetics industries as avocado seed can be processed to get avocado oil which can serve as high source of nutrient in the production of cosmetics to enhance the skin's good looking condition.

Avocado seed will attain a value of 2352.200N force at peak and any value higher than this; will cause it to break when determining the effect of moisture content on avocado seed along longitudinal loading. In the same vein, avocado seed will attain a value of 1497.000N force at peak and any value higher than this; will cause it to break when determining the effect of moisture content on avocado seed along axial loading.

It should be noted that value at break point could be automatic or manually decided depending on the brittleness of specimen and that break points are reached after rupture as taken place at peak points.

### **Recommendation**

Further study should be carried out on how to design machines and equipment for storage, processing, handling and transportation of avocado pulp and seed from the data generated. Further research should be carried out on how to use the various data obtained for

mechanical and thermal properties of avocado pulp and seed for oil extraction and usage for medicinal purposes.

## References

- [1] Okafor S.O. (2003). Determination of some physical properties of Dika nut seed. *The Pacific Journal of Science and Tech.* 12(2): 227-250.
- [2] Dutta, S.K., V.K. Nema and R.K. Bhardwaj, 1988. Physical properties of gram. *J. Agric. Eng. Res.* 39: 259-268.
- [3] Maduako, J.N. and M.O. Faborode, 1990. Some physical properties of cocoa pods in relation to primary processing. *Ife J. Technol.* 2(1): 1-7.
- [4] Aviara, N.A. and M.A. Haque, 2001. Moisture dependence of thermal properties of sheanut kernel. *J. Food Eng.* 47: 109-113.
- [5] Aviara, N.A., E. Mamman and B. Umar, 2005. Some physical properties of balanites aegyptiaca nuts. *Biosyst. Eng.* 92(3): 325-334.
- [6] Vishwa N. Verma, Application of atomic absorption spectroscopy to food sciences (A study on *Persea americana* Mill – Avocado). *World Scientific News* 49(2) (2016) 104-116
- [7] Tsegay Hiwot, Determination of oil and biodiesel content, physicochemical properties of the oil extracted from avocado seed (*Persea americana*) grown in Wonago and Dilla (gedeo zone), southern Ethiopia. *World Scientific News* 58 (2016) 133-147
- [8] K. Nwaokobia, R. O. Ogboru, C. A. Idibie, Extraction of edible oil from the pulp of *Persea americana* (Mill) using cold process method. *World News of Natural Sciences* 17 (2018) 130-140
- [9] Mieszkalski, I. 1997. The role of physical properties of seeds in the design of dehullers. *International Agrophysics*, 11: 283-291.
- [10] Sacilik, K., R. Ozturk and R. Keskin. 2003. Some physical properties of hemp seed. *Biosystems Engineering*, 86: 191-198.
- [11] Aviara, N.A., M.A. Haque and L.A.O. Ogunjimi, 2008. Thermal properties of gona seed. *Int. Agrophys.* 22: 291-297.
- [12] Guardado-Valdivia L, Tovar-Pérez E, Chacón-López A, López-García U, Gutiérrez-Martínez P, Stoll A, Aguilera S. Identification and characterization of a new *Bacillus atropheus* strain B5 as biocontrol agent of postharvest anthracnose disease in soursop (*Annona muricata*) and avocado (*Persea americana*). *Microbiol Res.* 2018 May; 210: 26-32.
- [13] Flores-Alvarez LJ, Guzmán-Rodríguez JJ, López-Gómez R, Salgado-Garciglia R, Ochoa-Zarzosa A, López-Meza JE. PaDef defensin from avocado (*Persea americana* var. *drymifolia*) is cytotoxic to K562 chronic myeloid leukemia cells through extrinsic apoptosis. *Int J Biochem Cell Biol.* 2018 Mar 17; 99: 10-18.

- [14] Soldera-Silva A, Seyfried M, Campestrini LH, Zawadzki-Baggio SF, Minho AP, Molento MB, Maurer JBB. Assessment of anthelmintic activity and bio-guided chemical analysis of *Persea americana* seed extracts. *Vet Parasitol.* 2018, Feb 15; 251: 34-43.
- [15] María Elena Pahua-Ramos, Alicia Ortiz-Moreno, Germán Chamorro-Cevallos, María Dolores Hernández-Navarro. Hypolipidemic Effect of Avocado (*Persea americana* Mill) Seed in a Hypercholesterolemic Mouse Model. *Plant Foods for Human Nutrition* March 2012, Volume 67, Issue 1, pp 10–16
- [16] Ortiz MA, Dorantes AL, Galindez MJ, Cárdenas SE (2004). Effect of a novel oil extraction method on avocado (*Persea americana* Mill) pulp microstructure. *Plant Foods Hum Nutr* 59(1): 11–14