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Some Mechanical Properties of Moringa *Oleifera* Seeds

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ABSTRACT

The success of any agricultural engineering design effort is determined largely by the availability of data on the engineering properties that are useful in machine design for planting, harvesting, handling to packaging. In this study, some mechanical properties of Moringa seeds were carried out. Angle of repose and coefficient of friction were determined on five different surfaces namely: glass, aluminium, wood, plastic and galvanized steel. Compression strength test was carried out using a universal testing machine. At a moisture content of 8.33% wet basis, the surface with the highest angle of repose and coefficient of friction is galvanised steel with average values of 18.84^o and 0.3412 respectively, while glass surface has the lowest, with average values of 15.06^o and 0.2691 respectively.The average force at break and force at yield are 63.19N and 32.06N respectively.These properties are necessary for the design of equipment for harvesting, processing, transporting, separating, packing and storage processes.

Key words: Angle of repose, Coefficient of friction, Compression strength, force at yield, Mechanical properties, Moringa seeds

INTRODUCTION

Moringa *oleifera* is esteemed as a versatile plant due to its numerous uses. The leaves, fruits, flowers and mature pods of the tree are edible and they form part of traditional diets in many countries of the world. [1]. The leaves and seeds of Moringa *oleifera* seed are good sources of protein, vitamin A, B, C and minerals such as calcium and iron [2]. In addition to its substantial uses and nutritional benefits; it also has a great potential as a medicinal plant.

The flowers, leaves and roots are used for the treatment of rheumatism and venomous bites and as cardiac and circulatory stimulants in folk's remedies. The seeds of the plant can be processed or cooked for consumption. It can also be processed into powdered state which can be traditionally used as coagulating agent in water purification [3] [1]. Moringa *oleifera*, kernels also contains a significant amount of oil which is commonly known as Ben oil or Behen oil.

Due to the facts that they are harvested traditionally by handpicking, the harvested seeds always contained dirt and unwanted materials which necessitate cleaning.

[4] [5] [6] reported that repeated effect of grain losses during storage is sometimes considered as a problem of poor storage structure in terms of choice, design or construction, which is largely governed by the physical and mechanical properties of the crop. Physical and mechanical properties relationship was needed to describe the crop responses to external forces [7]

The mechanical properties of material govern their behavior under the effect of mechanical forces. Forces acting on a mechanical device causes deformation and flow (creep) in it and nature of the force is the primary factor in determining the response of a given material [8].

Friction plays important roles in all fields of agricultural mechanics. It is always present in some form during the movement of bodies and it effect of the force which is to be exerted. In silo bin and other storage structures the vertical load on the wall is determined by the friction coefficient [9]

To further process harvested seeds there are need for the determination of some engineering properties, such as physical and mechanical properties among others. The knowledge of these properties is highly relevant due to the increasing economic importance of food materials, together with the complexity of modern technology for their production, handling, storage, and processing. These demands comprehensive information on its properties which are of prime importance. These properties are important in the design and evaluation of the machines for processing of the seed. In the present study, the mechanical properties considered were: angle of repose, coefficient of friction, stress, strain and energy at break and rupture; and young modulus.

Experimental Procedure

Moringa *oleifera* seeds were locally sourced for at J.V.O Ventures in Ibadan Oyo State Nigeria. The pods were carefully broken in order to liberate the seeds. The seeds were manually cleaned from foreign materials. The moisture content determination was carried out using an electrically powered oven with great accuraccy, direct and precised method according to [10]. The value of the moisture content was then computed the equation 1.

$$\% \, M.C_{wb} = \frac{Ww}{Ww + Wd} \times \frac{100}{1} \quad (1)$$

Where W_w = Weight of water (g), W_d = Weight of dry seeds (g)

The Angle of Repose was determined by using the apparatus shown below, which consist of a wooden box of 700 x 150 x 120mm, with a screw jack attached to it.

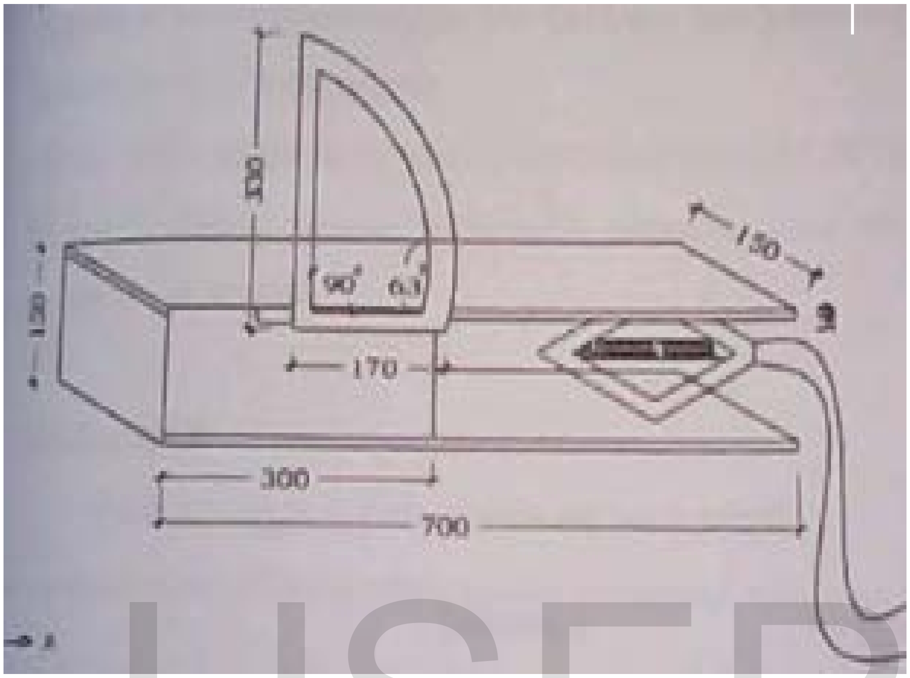

Fig.1. Apparatus for measuring angle of repose

The box (sample) was filled with the sample and then the adjustable plate was inclined gradually allowing the seeds to flow and assumed a natural slope, this measured emptying angle of repose (θ). Static coefficient of friction (μ) was determined using the equation 2.

$$\mu = \tan\theta \qquad (2)$$

Compression strength test was carried out using a universal testing machine (Santam, MRT-5) shown in Plate 1. The machine was used to compress the materials to obtain values for stress, strain, energy at rupture and at yield point; and young modulous. The seeds were loaded and compressed at a natural position at rest. The testing machine was controlled by a microcomputer, which allowed the user to control the speed and direction of the compression plate, and to automatically collect data.

Plate 1: Universal Testing Machine

RESULTS AND DISCUSSION

The moisture content of the seed was found to be 8.33% dry basis. Tables 1 and 2 give summaries of angle of repose and friction anglerespectively. The behavior of the seeds under compression load is also summarized in Table 3 below

Table 1. Angle of Repose on Different Surfaces

Material	Glass	**Plastic**	**Steel**	**Plywood**	**Aluminium**
Minimum Value (^{o})	14.8	16	18.5	18.5	15.7
Mximum Value (^{o})	15.4	16.8	19.2	19.2	16.3
Mean Value (^{o})	15.06 (±0.24)	16.56 (±0.34)	18.84 (±0.32)	18.84 (±0.32)	15.96 (±0.23)

Figures in parenthesis represent the standard deviation

Table 2. Coefficient of Static Friction on Different Surfaces

	Glass	**Plywood**	**Aluminum**	**Plastic**	**Steel**
Minimum	0.2642	0.2868	0.3346	0.3343	0.2811
Maximum	0.2756	0.3019	0.3482	0.3482	0.2924
Mean	0.2691 (±0.005)	0.2974 (±0.006)	0.3412 (±0.006)	0.3372 (±0.006)	0.286 (±0.006)

*Figures in parenthesis represent the standard deviation

Table 3. Compression Analysis Result

	Minimum Value	**Maximum Value**	**Mean**
Force @ Break (N)	39.2	93.1	63.19
Stress Break (N/mm^2)	39.2	93.1	63.19

Energy to Break (J)	0.0697	0.1862	0.1219
Force @ Yield (N)	9.90	64.5	32.06
Stress Yield (N/mm^2)	9.90	64.5	32.06
Energy to Yield (J)	0.0064	0.098	0.0429
Young Modulus(N/mm^2)	62.13	207.39	158.53

Discussions

The values for both angle of repose and coefficient of friction with respect to different surfaces are presented in Table 1 and 2 respectively. The surface with the highest angle of repose and coefficient of friction is galvanised steel with 18.84^o and 0.3412 respectively, while glass is the surface with the lowest angle of repose and coefficient of friction, with average values of 15.06^o and 0.2691 respectively. The coefficient of friction is used to determine the angle at which chutes must be positioned in other to achieve consistent flow of material through it [11].The angle of repose determines the maximum angle of a pile of grain in the horizontal plane and is important in the filling of a flat storage facility when grain is not piled at a uniform bed depth rather is peaked. This property is of paramount importance in determining the steepness of the storage container, hopper or any other loading and unloading device

The results of the compression analysis are presented in Table 3. The least stress for rupture and at yield point of the seeds was 39.2N/mm^2 and 10.2N/mm^2 respectively while the maximum stress at rupture and at yield point of the seeds were 93.1N/mm^2 and 51.9N/mm^2 respectively. The stress at rupture is an indication of the force per unit area on the seed that is sufficient to cause cell rupture of the seed.

The maximum energy at rupture and at yield point was 0.1862Jand 0.0756J respectively. The nature and types of threshing surface can either be determined with reference to the known maximum energy at rupture of the seeds.

The total impact that can be generated either by the threshing cylinder can be related to energy both at rupture and at yield point of the seeds. Table 3 shows the variation in the load at rupture and at yield point for the seeds. The minimum value for the young modulus is 62.13 N/mm^2, while the maximum is 207.39 N/mm^2.

CONCLUSION

Coefficient of friction, angle of repose and the behavior of the seed under load were investigated for Moringa *olifera* seed .The parameters were obtained and determined at the moisture content of 8.33%wb.

The surface with highest angle of repose and coefficient of friction were obtained for galvanised steel with average values of 18.84^o and 0.3412 respectively, while glass surface have the lowest angle of repose and coefficient of friction with average values of 15.06^o and 0.2691 respectively.

The maximum load at rupture and yield point were found to be 93.1N and 51.9N.

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