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MECHANICAL BEHAVIOUR OF MORINGA OLEIFERA SEEDS UNDER COMPRESSION LOADING

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ABSTRACT

Mechanical properties of Moringa oleifera of relevance to seed handling were determined. The properties determined were force, deformation, stress and energy at various compression loadings (peak, break, and yield), including the young modulus. The peak value occurs at force of 76N, strain of 41 for undehusked while for dehusked, the peak value for force is 96N and for strain is 64 respectively. The linear relationship at the peak, break and yield point was observed to be $y = 0.253x + 48.72$; $y = -0.004x + 59.68$ and $y = -0.076x + 25.40$ respectively. The results shows that the force correlation was positively weak (0.1842) at peak point and negatively weak (-0.0375 and -0.0918) at break and yield point respectively. The dehusked Moringa seeds possessed a relatively higher average force and stress than the undehusked seed at peak and break point, and otherwise at yield point, the inverse was the case of its energy properties. The young modulus of the undehusked seeds was however greater than the dehusked seeds and the elasticity for dehusked seed was also observed to be higher than undehusked moringa seed. Linear relationships that could be used at various compression loadings were established for both the undehusked and dehusked Moringa seeds.

Keyword head: Compression, Energy, Force, *Moringa oleifera*, Oilseed

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1. INTRODUCTION

Oilseeds (*Brassica napus*) represents the main raw material for vegetable oils extraction; they are in fact seen as main providers of superior great and specialty vegetable oils to dietary merchandise, herbal meals and premium snack food throughout the world. Oil producing plants includes Camelina, Crambe, Corn, Peanut, Rapeseed, Coconut, Oil palm and Olives etc. Majority of the countries producing oilseeds does so for the purpose of oil extraction. The oil content of small grains (e.g. wheat) is just 1 to 2%, however that of oilseeds levels from about 20% for soybean to over 20% for sunflower and rapeseeds like canola. Oilseeds are the biggest source of vegetable oils despite the fact that most oil-bearing tree fruits (such as olive, coconut and palm trees) provide the highest oil yields (Gunstone, 2002; Sarwar, 2013). Their high protein content also makes them fit to be used in animal feed; their seeds contain energy for the sprouting embryo mainly as oil, compared with cereals, which contain the energy in the form of starch (McKevith, 2005).

The fact that oilseeds are harvested by means of handpicking makes the seeds usually contained dirt and undesirable materials which necessitate cleaning (Appert, 1987; Birewar, 1990; Bell and Mazaud 1999). They stated that repeated impact of grain losses during storage can be considered as a problem of bad storage facilities with respect to its layout or construction, which is basically dictated by crop's physical and mechanical properties. This implies that, physical and mechanical properties relationship is needed to describe the crop responses to external forces (Daffala *et al.,* 1992). Oil raw materials are subjected to mechanical forces in the course of the oil extraction process; these forces lead to seed deformation and become the number one element in determining the reaction of a given material. Therefore, the mechanical properties of oil seeds have an important position in oil extraction (Ozumba and Obiakor, 2011).

Moringa oleifera, (from the Moringaceace family) is a plant that is frequently known as the drumstick tree, the miracle tree, the ben oil tree, or the horseradish tree. It is native to India but also grows in Africa, Asia, and South America. Moringa has been used for hundreds of years due to its medicinal properties and fitness advantages. Deeper research on Moringa has highlighted many of its other importance, one of which is the extraction of oil thereby making it an oilseed.

As earlier mentioned, mechanical properties of oilseeds are primary attribute which should be studied, although many researchers have carried out research to highlight some physical and mechanical attributes of divers oilseeds (Lucas and Olayanju, 2003; Olayanju and Lucas 2004; Bagvand and Lorestani, 2013; Jafari *et al.,* 2011; Khodabakhshian *et al.,* 2010), this research work was carried out to highlight and observe the relationship

2. MATERIALS

2.1. MATERIALS & EXPERIMENTAL PROCEDURES

2.1.1. Cleaning of Moringa Seeds

Fifty pieces of Moringa seeds were conveyed to the experimental site in dry bag in order to maintain a favourable conducive environment. The seeds were cleaned manually to remove foreign matters such as dust, dirt, sand, dry leaves and empty capsules. The moisture contents of the seeds were determined by the oven drying method (ASAE Standards, 1998). A method described by Kachru et al., (1994) was used to adjust seeds to the desired moisture content. Dehusked and undehusked Moringa seeds were prepared by using Federal Institute of Industrial research, Oshodi (FIIRO) established method.

2.1.2. Laboratory Testing

Compression tests were performed on Moringa seeds using the Monsanto Universal Testing Machine (Olayanju and Lucas, 2004). The testing conditions for the lnstron Machine were test speed 50mm/min, off preload, none for speed 2 tests. The procedure used by Braga *et al.* (1999) was followed. Ten samples, each of Moringa seed in both dehusked and undehusked form were used for the test. Each seed was placed between the compression plates of the tensonometer. The seed was compressed at a constant deformation rate of 50mm/min. The applied force at rupture and oil - point and their corresponding deformations for each seed sample was read directly from the force-deformation curve. The mechanical behaviour of Moringa seed was expressed in terms of force required for maximum strength of the seed, energy required to deform the seed to initial rupture and the seed specific deformation. The rupture force was determined as the force on the digital display when the seed under compression makes a clicking sound. Each process was often completed whenever the break point of the positioned seed is reached.

Figure 1: Universal Testing Machine

2.2. Methods

2.2.1. Methods of Analysis

The values obtained for force, deformation, stress and energy at various compression loadings (peak, break, and yield), including the young modulus was described using statistics such as minimum, mean, maximum, standard deviation (std. dev.) and standard error (std. error) for both dehusked and undehusked moringa seeds. The linear relationships between the mechanical properties of the dehusked and undehusked Moringa seeds at various compression loadings was also shown through a plotted graph; regression and correlation statistics were also performed.

3. RESULTS AND DISCUSSION

Descriptive Mechanical Properties of Undehusked (Height 10.8mm) and Dehusked (Height 7.5mm) Moringa Seed

Table 1-2 statistically describes the mechanical properties of *Moringa Oliefera* at different comprehension loadings.

Table 1 Mechanical Properties of Undehusked Moringa Oliefera at different compression loadings

Compression Loadings	Mechanical Properties	Mean	Std. Dev.	Std. Error	Maximum	Minimum
Peak	Force	58.61	13.7492	4.3479	76.6	33.5
	Deformation	3.9522	1.1472	0.3628	5.3140	2.1420
	Stress	58.21	12.6441	3.9984	70.4	33.5
	Energy	0.1178	0.0549	0.0174	0.2218	0.0496
Break	Force	53.49	12.9339	4.0901	70.4	33.5
	Deformation	4.7515	0.8667	0.2741	6.0530	2.6980
	Stress	53.99	13.0647	4.1314	70.4	33.5
	Energy	0.1564	0.0711	0.0225	0.2699	0.0496
Yield	Force	24.46	15.5403	4.9143	61.4	8.6
	Stress	24.46	15.5403	4.9143	61.4	8.6
	Energy	0.0135	0.0123	0.0041	0.0380	0.0029
Young Modulus		228.692	178.3101	56.3866	580.24	52.7

Table 2 Mechanical Properties of Dehusked Moringa Oliefera at different compression loadings

Compression Loadings	Mechanical Properties	Mean	Std. Dev.	Std. Error	Maximum	Minimum
Peak	Force	63.6	18.9550	5.9941	96.4	35
	Deformation	4.0110	0.8277	0.2617	5.2260	2.5250
	Stress	63.6	18.9550	5.9941	96.4	35
	Energy	0.0948	0.0276	0.0087	0.1496	0.0596
Break	Force	59.42	16.7194	5.2871	86.4	35
	Deformation	4.2789	0.6664	0.2107	5.2260	3.1090
	Stress	59.42	16.7194	5.2871	86.4	35
	Energy	0.1092	0.0309	0.0098	0.1691	0.0596
Yield	Force	23.54	12.9091	4.0822	53.5	7.1
	Stress	23.54	12.9091	4.0822	53.5	7.1
	Energy	0.0191	0.0115	0.0036	0.0401	0.0034
Young Modulus		120.687	60.3843	19.0952	270	55.84

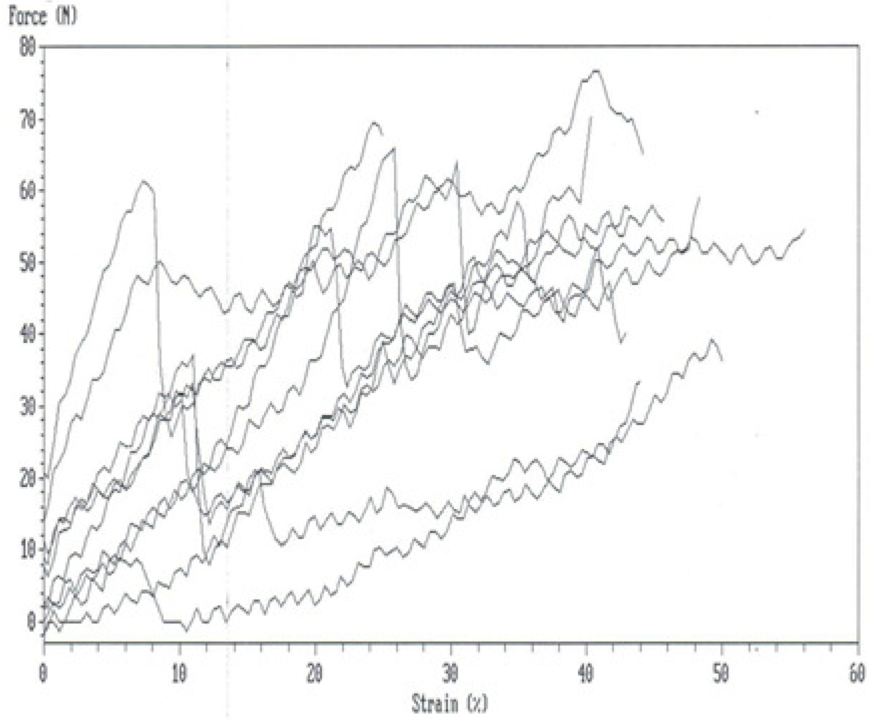

Figure 2a Elastic behaviour of undehusked moringa seed under compression loading

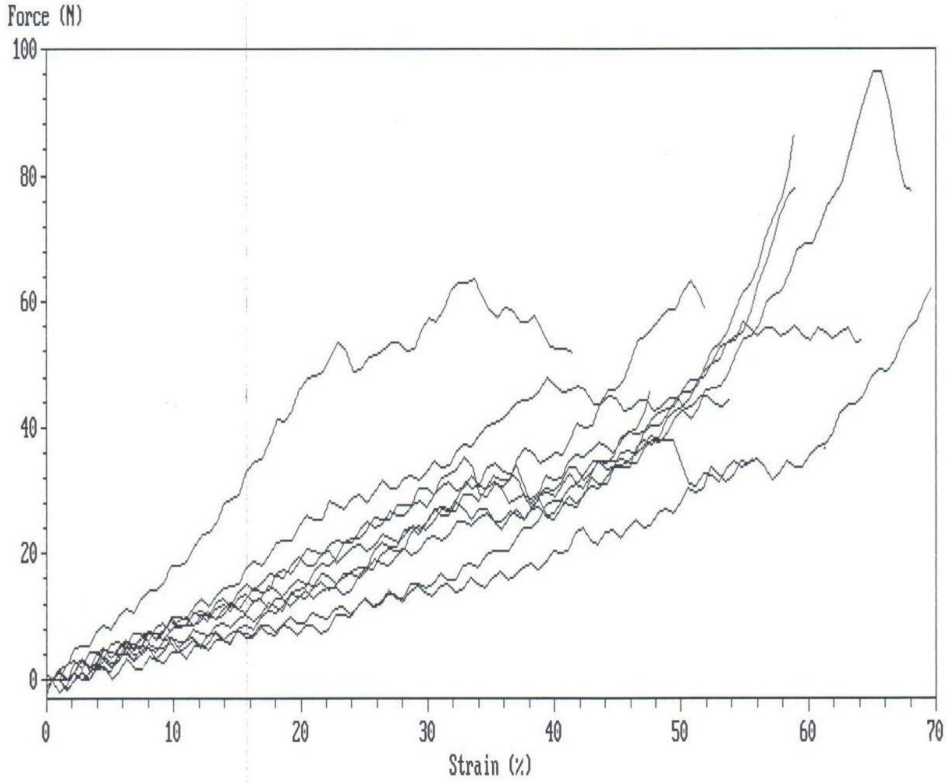

Figure 2b Elastic behaviour of dehusked moringa seed under compression loading

From Figures 2a and 2b, it was deduced that the peak value occur at force of 76N, strain of 41 for undehusked while for dehusked, the peak value for force is 96N and for strain is 64. Thus, it can be clearly observed that the elasticity for dehusked is higher than undehusked.

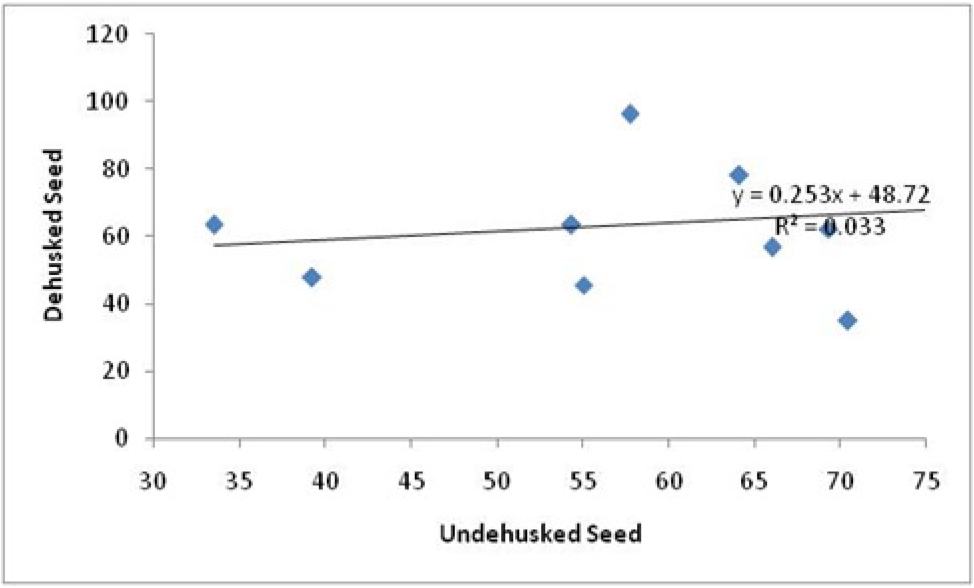

Figure 3a Force Relationship at Peak Point

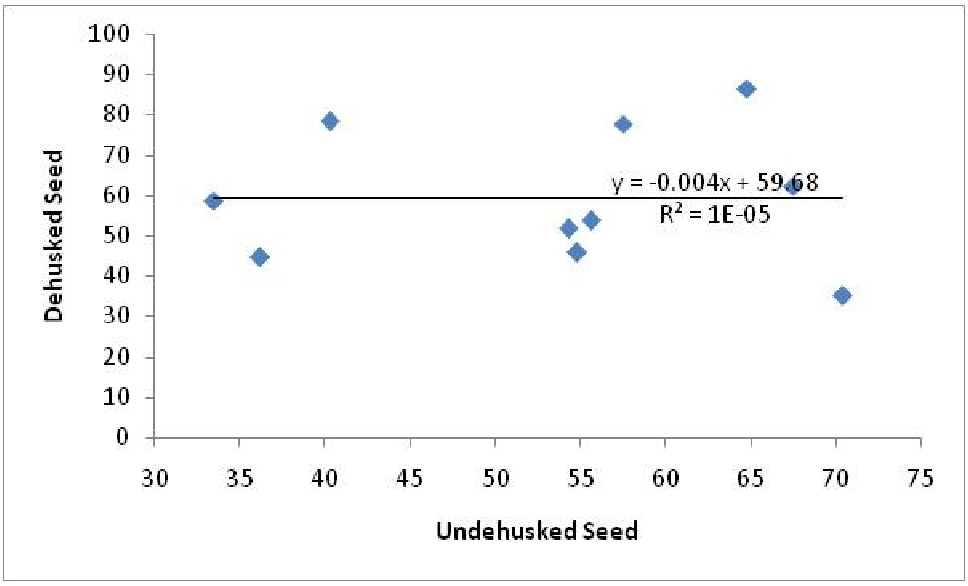

Figure 3b Force Relationship at Break Point

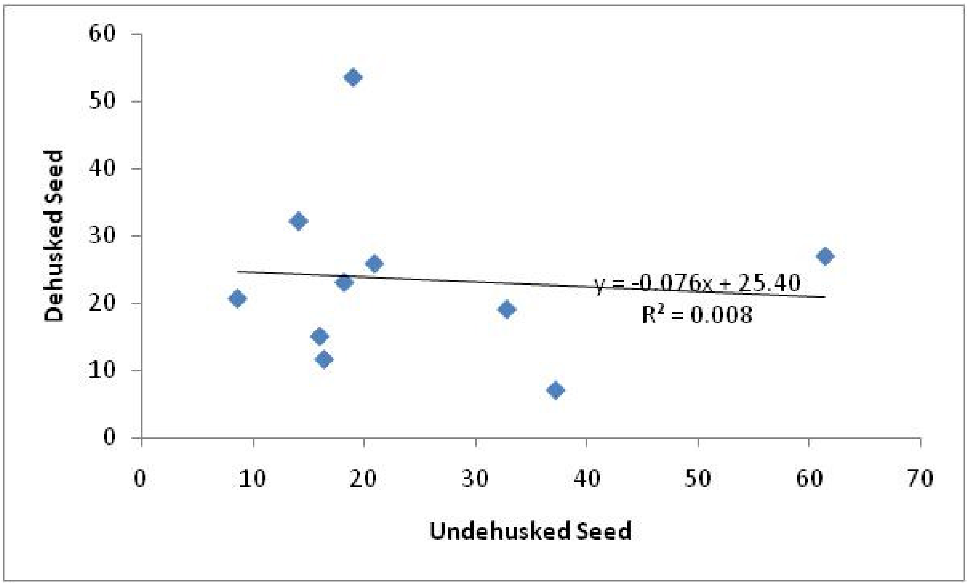

Figure 3c Force Relationship at Yield Point

The force relationship between dehusked and undehusked *Moringa oliefera* at various points are shown in Figures 3a to c; the linear relationship at the peak, break and yield point was observed to be y = 0.253x + 48.72, y = -0.004x + 59.68 and y = -0.076x + 25.40 respectively. However, the extremely low values of their respective R squares (0.033, 0.00001 and 0.008) infers a very little explanation in the linear model's variation and can be statistically termed as the inability to adequately use only the force of the undehusked Moringa to explain that of the dehusked. The force correlation was calculated to be positively weak (0.1842) at peak point and negatively weak (-0.0375 and -0.0918) at break and yield point respectively.

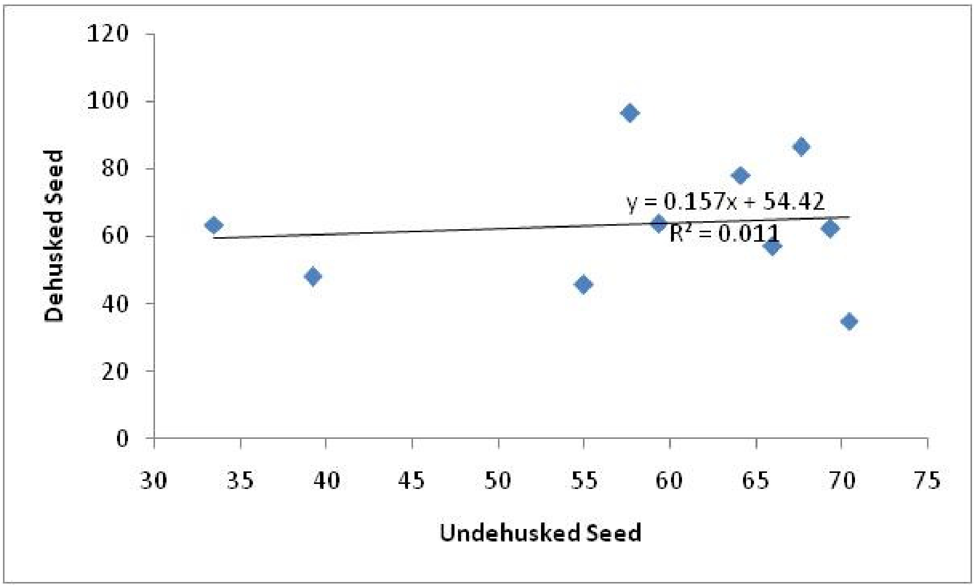

Figure 4a Stress Relationship at Peak Point

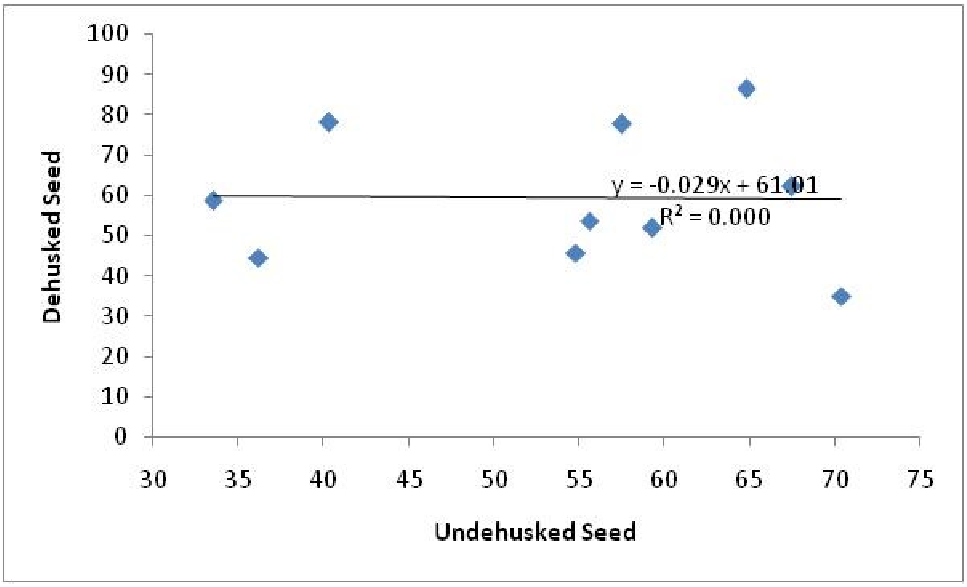

Figure 4b Stress Relationship at Break Point

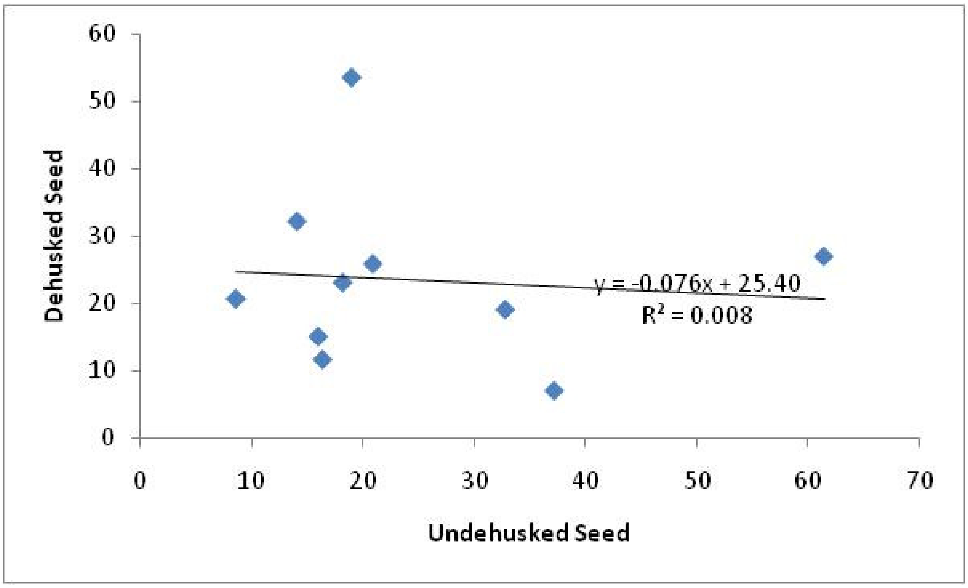

Figure 4c Stress Relationship at Yield Point

The stress relationship between dehusked and undehusked *Moringa oleifera* at various points are shown in Figures 4a to c; the linear relationship at the peak. Break and yield point was observed to be y = 0.253x + 48.72, y = -0.029x + 61.01 and y = -0.076x + 25.40 respectively. Just as the case for force relationship, the extremely low or zero values of their respective R squares (0.033, 0.000 and 0.008) infers a very little explanation in the linear model's variation and can be statistically termed as the inability to adequately use only the stress of the undehusked moringa to explain that of the dehusked. The stress correlation was also calculated to be positively weak (0.1842) at peak point and negatively weak (-0.0231 and -0.0918) at break and yield point respectively.

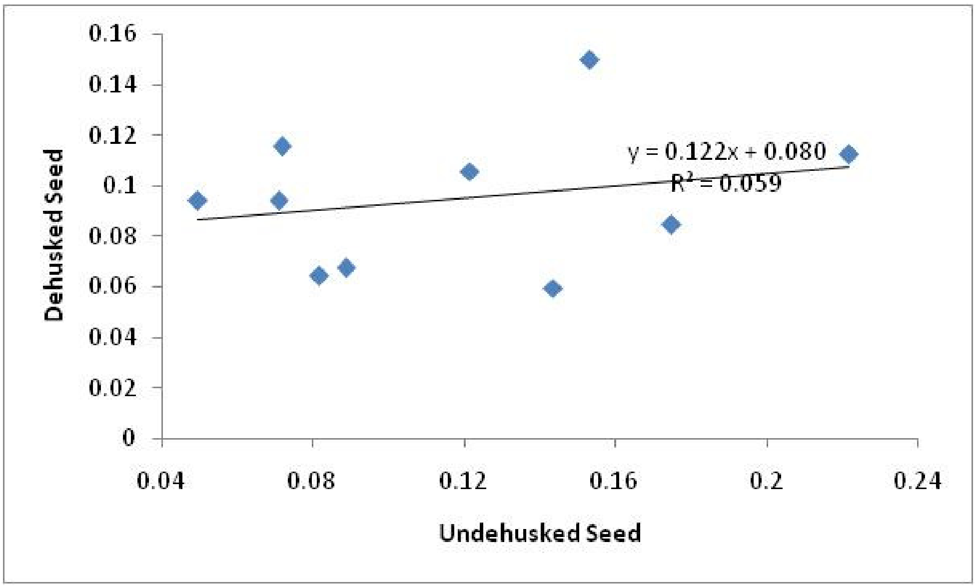

Figure 5a Energy Relationship at Peak Point

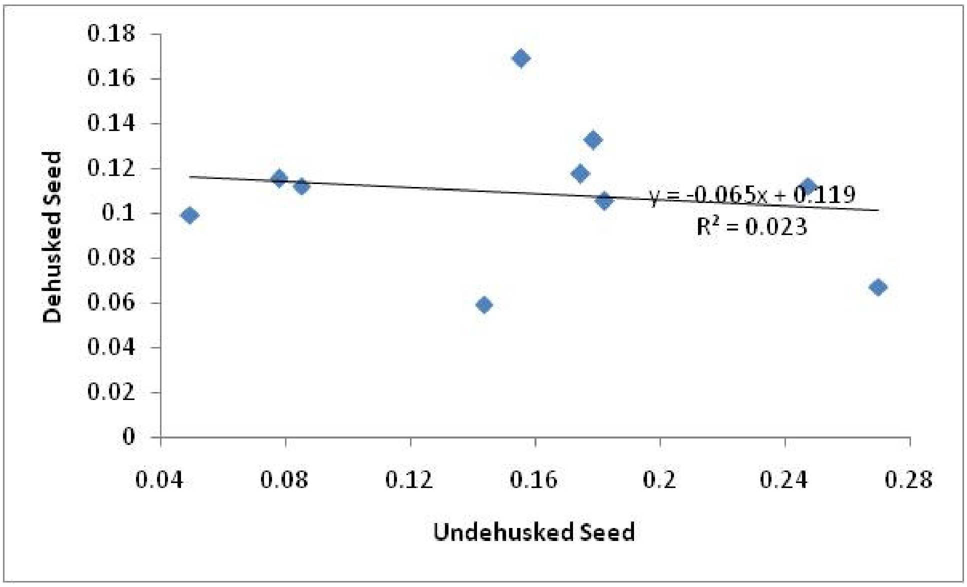

Figure 5b Energy Relationship at Break Point

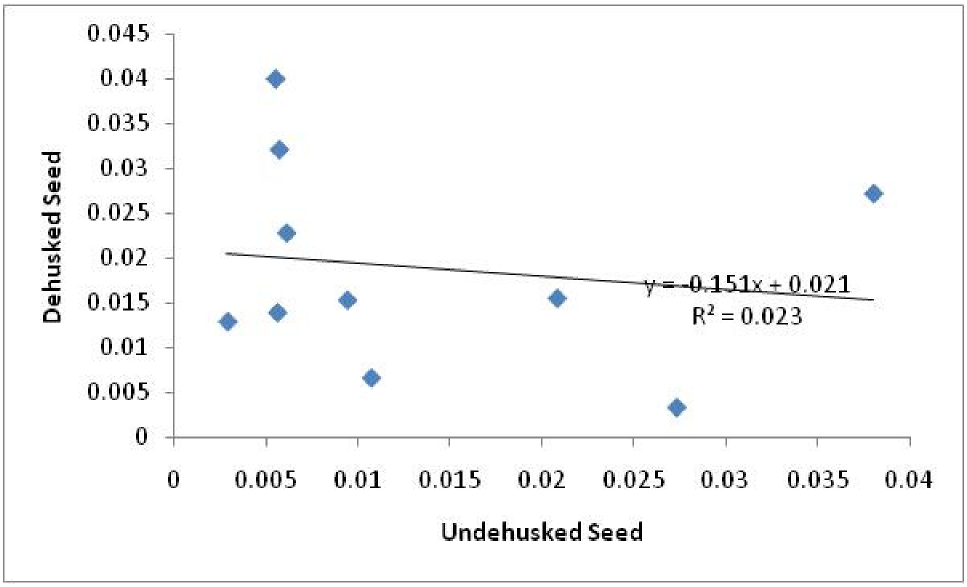

Figure 5c Energy Relationship at Yield Point

The energy relationship between dehusked and undehusked *Moringa oliefera* at various points are shown in Figures 5a to c; the linear relationship at the peak. Break and yield point was observed to be y = 0.122x + 0.080, y = -0.065x + 0.119 and y = -0.151 + 0.021 respectively. The extremely low values of their respective R squares (0.059, 0.023 and 0.023) also infer a very little explaination in the linear model's variation which implies the inability to adequately use only the energy of the undehusked Moringa to explain that of the dehusked. The energy correlation was also calculated to be positively weak (0.2429) at peak point and negatively weak (-0.1517 and -0.1537) at break and yield point respectively.

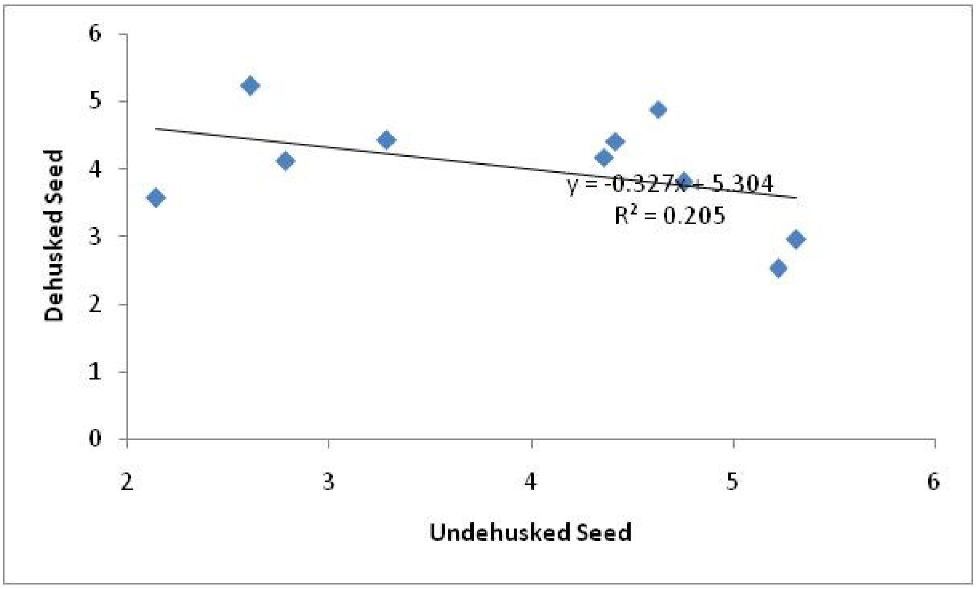

Figure 6a Deformation Relationship at Peak Point

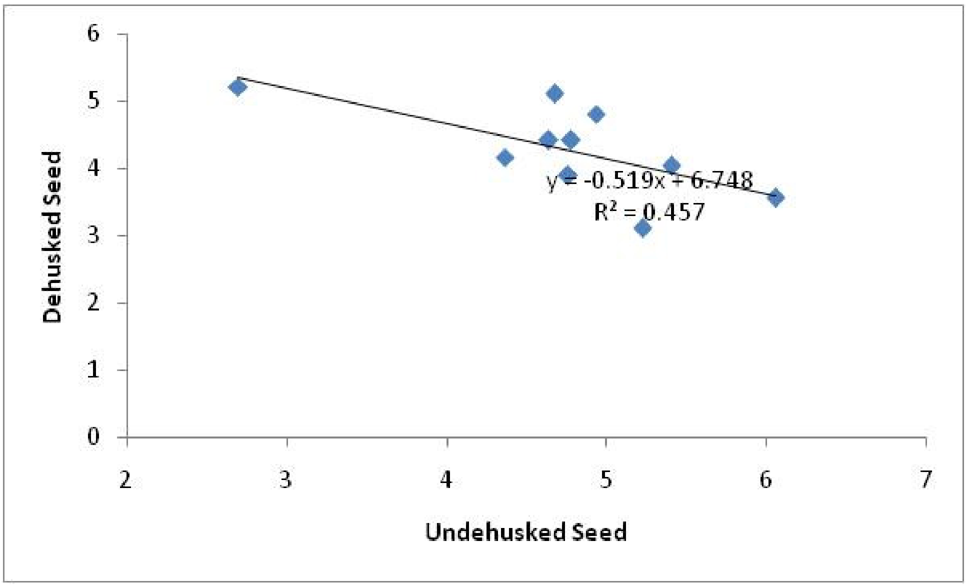

Figure 6b Deformation Relationship at Break Point

The deformation relationship between dehusked and undehusked *Moringa oliefera* at peak and break point is shown in Figures 6a and b respectively; the linear relationship at the peak and break point was expressed mathematically as y = -0.327x + 5.304 and y = -0.519x + 6.748 respectively. The R squared value of the deformation relationship at break point is 0.457 which implies that the model is 45.7% sufficient to explain variations between the undehusked and dehusked Moringa. However, the R squared (0.205) value of deformation relationship at break point is low. The deformation correlation between dehusked and undehusked moringa was calculated to be negatively weak (-0.4536) at peak point but strong (-0.6760) at break point.

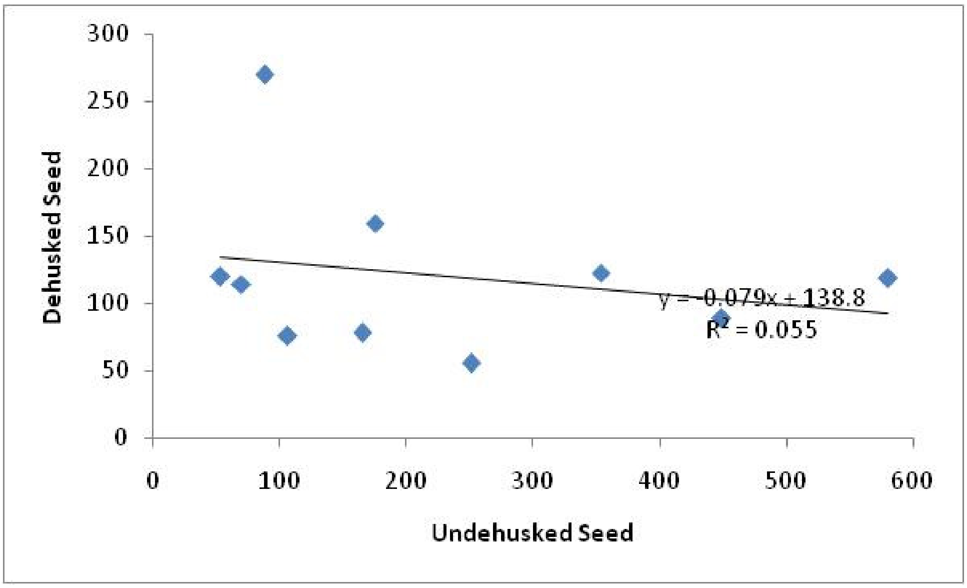

Figure 7 Young Modulus Relationships at Peak Point

The relationship between the young modulus behaviour of the dehusked and undehusked Moringa is shown in Figure 7 and can be expressed mathematically as y = -0.079x + 138.8. The R squared value is 0.055 which does not imply a sufficient variation explanation by the model. The correlation was calculated to be -0.2346 which is negatively weak.

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