2011

Federal University of Technology, Minna, Nigeria.

NJTR

FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA
Technology for Empowerment

Nigerian Journal of Technological Research.

Vol. 6 No. 1. 2011

- PURE AND APPLIED SCIENCES,
- ENGINEERING SCIENCES
- ENVIRONMENTAL SCIENCES
- AGRICULTURAL SCIENCES
- INFORMATION AND COMMUNICATION TECHNOLOGY
- MANAGEMENT AND ENTREPRENEURSHIP SCIENCES

Production supported by:
**Education Trust Fund (ETF)
Abuja, Nigeria.**

EDUCATION TRUST FUND

From The Vice-Chancellors Desk.

The Federal University of Technology, Minna, has continued to make giant strides in ensuring that quality academics are produced and showcased in the Nigerian, educational terrain. I find it most rewarding to note, that despite all constraints members of staff of The Federal University of Technology, Minna can rise up to the task of ensuring basic and upto date research information are generated from its domain.

I am particularly satisfied at this time as The Vice-Chancellor that members of staff of my university find joy in customizing themselves to the rising challenges of Information and Communication Technology (ICT), and indeed put themselves abreast of its advantages. It is important to say that scientific and technologically balanced minds are usually not at rest until they make moves to show that their results have a basis. I am therefore glad that members of staff have taken the challenge of the rejuvenation of The Nigerian Journal of Technological Research to present their research outputs.

I would like to encourage contributors to scientific journals not to limit themselves to the use of journal publications to obtaining their promotions. The essence of journal publications is beyond promotion exercise. It has the capacity to expose diligent scientists to challenges in their field of research and brings about competition and bridging of gap in knowledge dissemination. This is necessary in a developing nation like ours. A specialist University such as ours must find this challenging and rise up to the task in whatever we present to the public.

The University is determined to ensure that distinguished scholarly studies are given the enabling environment to thrive and also, encourage young and upcoming scientists adequate training ground to obtain the best. The effort of intervening agencies such as The Education Trust Fund (ETF), Abuja and The Federal Government of Nigeria through The University Council and Senate in encouraging academic staff in this University must be commended and the reciprocation of such gestures by the beneficiaries needs to be noted. It is my hope that all hands will be on deck to ensure that the next edition of The Nigerian Journal of Technological Research will highlight higher and challenging research findings.

Professor M. S. Audu, Vice- Chancellor, Federal University of Technology, Minna.

Editorial Comment

The volume six number one of this journal, has been specifically packaged and dedicated to showcase scientific works from The Federal University of Technology, Minna. In doing so, effort has been made to present top class articles from varied levels of discipline within the arcades of programmes run by The Federal University of Technology, Minna. The volume of research activities in The Federal University of Technology, Minna cannot be substantially displayed in a journal of this nature; but the products reflected in it will help to provide an insight into the scholarly terrain of this great institution.

The provision of standard scholarly articles which can give immediate and current information to the scientific community is pertinent in a developing nation like Nigeria. Its various academic institutions therefore form the gateway for obtaining this information. The Editorial Board has carefully received, reviewed and published very topical materials in this edition which will meet the standard of academic excellence anywhere in the world. This has helped to give credence to the effort of intervening institutions such as The Education Trust Fund (ETF) who have helped to provide reasonable funds in ensuring a sustainability of the provision of this avenue for the teaming scientists in the Nigerian educational system.

One feature of this edition is the articles from the library information services of The Federal University of Technology, Minna. This goes to buttress the effort, the institution has been making to inculcate the culture of research into all areas of service within its domain. With the continued growth and development of The Nigerian Journal of Technological Research, it is anticipated that it will soon provide ground breaking research outputs which will help in overcoming some national and international economic problems that will be beneficial to mankind.

Finally, The Editorial Board is poised to ensure that the standard and quality of output from The Nigerian Journal of Technological Research continues to be improved upon and meets the desires of contributors and ultimate users. We appreciate all who have kept faith with the development of The Journal and The Federal University of Technology, Minna.

Editor-in-Chief, Nigerian Journal of Technological Research, Federal University of Technology, Minna.

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SOME ENGINEERING PROPERTIES OF PEANUT *(Arachis hypogaea)* AS RELEVANT TO AGRICULTURAL PROCESSING

, Balami, Audu Ayuba, Mohammed, Abubakar Sadeeq and Fadiji, Samuel Tobi, Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria.

ABSTRACT

In this study, selected engineering properties (shape, size, geometric mean diameter, sphericity, colour, seed mass, volume, particle density, bulk density, porosity, surface area, angle of repose, and compressive strength) of three improved varieties of peanut; SAMNUT 10, SAMNUT 11, and SAMNUT 22 of both the whole seed and the kernel were determined at moisture contents of 7.26%, 7.68%, 7.68%, 6.74%, 6.38% and 6.62% respectively. The highest value of compressive strength for whole seeds of SAMNUT 10, SAMNUT 11 and SAMNUT 22 are 115.80N, 1181.30N and 124.53N, while for the kernels are 78.83N, 88.93N and 83.09N respectively. For both the whole seeds and the kernels, SAMNUT 11 has the highest compressive load while, SAMNUT 10 has the lowest compressive load for both the whole seeds and the kernels relative to the other varieties. In operations such as shelling, crushing, and oil extraction of Peanuts, using these varieties, SAMNUT 11 requires a high force for compressing, while SAMNUT 10 requires a lesser compressive force. Therefore these results are important for maximum efficiency in designing equipment required for further processing of Peanuts and the reduction of mechanical damage to agricultural produce during post harvest handling, and processing.

Keywords: Engineering Properties of Peanut, Agricultural Processing

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Received: 18/03/2011
Accepted:22/06/2011

1. INTRODUCTION

Modern agriculture has brought about the handling and processing of plants and animal materials by various means ranging from mechanical, thermal, electrical, optical, to even sonic technique. Upon all these ever increasing application, little information is available on the basic engineering properties of these materials, particularly in Nigeria. The ever increasing importance of agricultural products together with the complexity of modern technology for their production, processing and storage need a better knowledge of the engineering properties of these products. It is however necessary to understand the physical laws guiding the response of these agricultural products so that machines, processes and handling operations can be designed for maximum efficiency and the highest quality of the final end products (Mohsenin, 1970).

Agricultural products especially those of the plant origin are now frequently used for a wide range of activities with importance of other increasingly emerging products. These agricultural products have over the years been underexploited in the regions of which they are produced especially in the developing countries. Kachru, *et. al.* (1994) reported that it is essential to determine the engineering properties of oilseeds (for example peanut) for proper design of equipment for handling, conveying, separation, dehulling, drying, aeration and mechanical expression of oil from these seeds. Therefore, the knowledge of the engineering properties of the products is important in the design of agricultural machinery, equipment and facilities.

The multifunctional use of peanut (peanut butter, oil, hay for livestock feed, husks as fuel, roughage, litter for livestock, mulch, manure, and as soil conditioners, used in sandwiches, candy, and bakery products, can be eaten both shell and nut, used in cosmetics, nitroglycerin, plastics, dyes and paints (Wikipedia, 2009), Peanuts contribute to brain health, brain circulation and blood flow. In addition to that, peanuts are also good antioxidants. Other health benefits of peanut include protection against colon cancer, prostate cancer, breast cancer, heart disease, and high cholesterol) makes it a necessity to determine the engineering properties of this extremely valuable agricultural product so that more extensive study can be conducted in order to determine and locate more areas of which the peanut is relevant.

Peanut, an important oil and food crop is currently grown on approximately 42 million acres worldwide. It is the third major oilseed of the world next to soybean and cotton (FAO Food Outlook, 1990). China, India, Nigeria and the United States have been the leading producers for over 25 years and grow about 70% of the world crop.

1.1 Statement of the Problem

The shortage of processing and preservative machines and equipment for peanuts, which may be due to the fact that data on the engineering properties of peanut required for the design of these machines are insufficient and not available in some cases.

1.2. Objectives of the Study

The objective of this study is to determine these selected engineering properties of peanut; (shape, size, colour, seed weight, volume, particle density, bulk density, porosity, surface area, angle of repose and compressive strength).

2. MATERIALS AND METHODS

2.1 Selection of Materials.

Peanut was selected as material for investigation. The seeds were obtained from the Seed Multiplication Unit of the Plant Science Department, Institute for Agricultural Research, Ahmadu Bello University, Zaria. Three species namely; SAMNUT 10, SAMNUT 11, and SAMNUT 22, were chosen for the experiment. The samples were numbered to avoid the use of the same seed or repeat of experiment with the same seed.

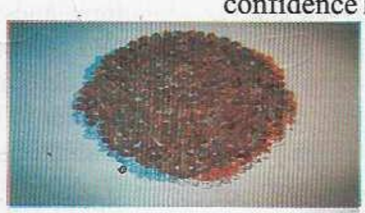
2.2. Determination of the Engineering Properties

The engineering properties of three chosen improved varieties of peanut; SAMNUT 10, SAMNUT 11, and SAMNUT 22 at moisture contents of 7.26%, 7.68%, 7.68%, 6.74%, 6.38% and 6.62% (shape, size, geometric mean diameter, sphericity, colour, seed mass, volume, particle density, bulk density, porosity, surface area, angle of repose, and compressive strength) were determined according to established standards and procedure (ASAE, 2003, Handerson et al., 1997).

Statistical Analysis

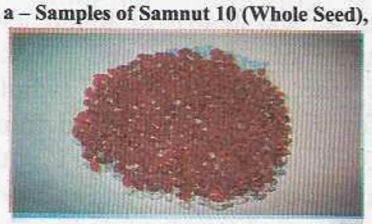
The tool used for computation and comparison are mean, standard deviation and coefficient of variation, and skewness, using Microsoft Excel 2007 at 95% confidence level.

a – Samples of Samnut 10 (Whole Seed),

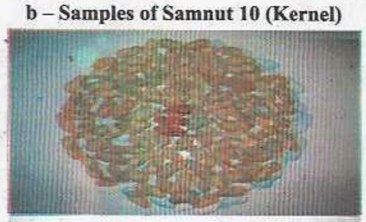


b – Samples of Samnut 10 (Kernel)

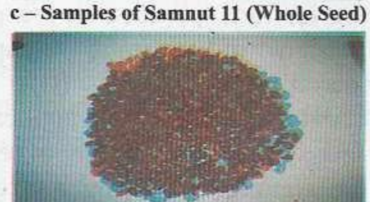
c – Samples of Samnut 11 (Whole Seed)



d - Samples of Samnut 11 (Kernel)



e - Samples of Samnut 22 (Whole Seed)



f - Samples of Samnut 22 (Kernel)

3. RESULTS AND DISCUSSION

The results of the experiments are presented in Appendixes 1 to 12, Table 1 and Figures 1 - 11 and at predetermined moisture contents (7.26 – 7.68 % - whole seed) and (6.62 – 6.74 % -kernel) for the samples used.

3.1 Discussion of Result on Physical Properties

It was observed from Appendixes 1 to 6 that the length (D1), width (D2), and thickness (D3) for whole seed of SAMNUT 10, SAMNUT 11, and SAMNUT 22 have mean values of 27.897 ± 0.285,13.490 ± 0.136,11.873 ± 0.209; 27.346 ± 0.174, 13.227 ± 0.085, 11.878 ± 0.067; 28.094 ± 0.470, 13.236 ± 0.087, 11.852 ± 0.111 respectively while that of the kernels for the three varieties have mean values of 14.213±0.292, 8.507 ± 0.098, 7.908 ± 0.109; 14.457 ± 0.234, 8.501 ± 0.163, 7.953 ± 0.147; 14.194 ± 0.193, 8.132 ± 0.130, 7.664 ± 0.122 respectively. With known axial dimensions, the product can be effectively graded. Sieves can now be designed within a range for separation of the seeds from the chaff. In the design of machine for processing, the knowledge of different dimensions is important so as to minimize wastage or breakage while grading, peeling, and dehusking.

The mean values of a thousand seed weight and the volume of the whole seed for SAMNUT 10, SAMNUT 11, and SAMNUT 22 are 1219 ± 114.080, 1466.667 ± 57.735; 1342.833 ± 36.385, 1666.667 ± 144.338, 1316.667 ± 54.351, 1466.666 ± 57.735 respectively while that of the kernels for the varieties are 459.667 ± 11.547, 500 ± 0, 482.167 ± 31.660, 616.667 ± 125.831, 442.333 ± 17.134, 500 ± 0 respectively. The weights of agricultural products are exploited in the design of cleaning equipment using aerodynamic forces (Oje and Ugbor, 1991), also practical application of seed mass is in the design of equipment for separation, conveying and elevating unit operations. The one thousand grain mass is a useful index in measuring the relative amount of dockage or foreign material in a given lot of material, and the amount of shriveled or immature kernels (Luh, 1980). The high variation in seed weight may likely be attributed to presence of immature seeds, damaged or unfilled seed.

The data on in Appendixes 7 to 12 gives the means, standard deviation and coefficient of variation of calculated values of calculated parameters of the peanut varieties of both the whole seed and the kernel. For SAMNUT 10 (whole seed), AMD has a mean of 17.753 mm ranging from 17.647 mm to 17.811 mm, GMD has a mean of 16.470 mm ranging 16.389 mm to 16.562 mm, SMD has a mean of 17.007 mm ranging from 16.913 mm to 17.081 mm, ED has a mean of 17.077 mm ranging from 16.983 mm to 17.149 mm, while the AMD, GMD, SMD and ED for the kernels of the same variety has means of 10.209 mm, 9.851 mm, 10.009 mm and 10.023 mm respectively. For SAMNUT 11, the means for the whole seed for AMD, GMD, SMD, and ED are 17.483 mm, 16.256 mm, 16.769 mm and 16.836 mm respectively while the means of the same parameters for the kernels are 10.304 mm, 9.924 mm, 10.091 mm and 10.106 mm respectively. The AMD, GMD, SMD and ED for SAMNUT 22 (whole seed) are 17.727 mm, 16.395 mm, 16.948 mm and 17.023 mm respectively and for the kernels the means are 9.997 mm, 9.600 mm, 9.773 mm, and 9.790 mm. The arithmetic mean and geometric mean can therefore be used to determine the average diameter of peanut. This is useful in determining the diameter of sieve hole.

Sphericity and aspect ratio ranged from 0.583 to 0.596 and 0.481 to 0.488 and mean values of 0.590 and 0.484 respectively for SAMNUT 10 (whole seed) and for the kernels, it ranged from 0.686 to 0.698 and 0.586 to 0.611 with mean values of 0.693 and 0.599 respectively. For SAMNUT 11, sphericity ranged from 0.589 to 0.597 with mean value of 0.594 and aspect ratio ranged from 0.477 to 0.487 with mean value of 0.484 for the whole seed, and for the kernel sphericity ranged from 0.677 to 0.694 with mean value of 0.687 and the aspect ratio ranged from 0.574 to 0.600 with mean value of 0.588. Sphericity for whole seed of SAMNUT 22 ranged from 0.578 to 0.590 with mean value of 0.584 and the aspect ratio ranged from 0.465 to 0.477 with mean value of 0.471 and for the kernels sphericity ranged from 0.669 to 0.684 with mean value of 0.676 and the aspect ratio ranged from 0.566 to 0.582 with an average value of 0.573. Sphericity values of most agricultural produce have been reported to range between 0.32 and 1.00 and the more regular an object is, the lower the sphericity (Mohsenin, 1970; Irtwange and Igbeka, 2002). Low aspect ratio Eke, *et. al.*, (2007) reported is the tendency to being oblong in shape. However, with an aspect ratio of over 70%, the peanut is more likely to roll than to slide. Sphericity of over 60% shows how close the shape of the peanut is to a sphere. Thus the kernels of the three varieties have the tendency to be close to a sphere, and also have the ability to slide or roll than the whole seed. This is important information for hopper, separation and conveying equipment design.

The particle density and the bulk density for SAMNUT 10 (whole seed) ranged from 0.782 g/cm^3 to 0.880 g/cm^3 with a mean value of 0.830 g/cm^3 and 0.289 g/cm^3 to 0.297 g/cm^3 with a mean value of 0.294 g/cm^3 respectively while for the kernels, particle density ranged from 0.906 g/cm^3 to 0.946 g/cm^3 with an average of 0.919 g/cm^3 and the bulk density ranged from 0.572 g/cm^3 to 0.582 g/cm^3 with a mean value of 0.576 g/cm^3. For the whole seed of SAMNUT 11, particle density has a mean value of 0.811 g/cm^3 and the bulk density has a mean value of 0.311 g/cm^3, while that of the kernel, particle density has a mean value of 0.797 g/cm^3 and that of bulk density is 0.589 g/cm^3. The whole seed of SAMNUT 22 has particle density with a mean value of 0.901 g/cm^3 while the mean value for the bulk density is 0.299 g/cm^3 and that of kernel is 0.885 g/cm^3 and 0.583 g/cm^3 for both the particle density and bulk density respectively. The particle density of agricultural products have been reported to play significant importance in the design of silos and storage bins, maturity and quality evaluation of products which are essential to grain marketing (Irtwange and Igbeka, 2002). Bulk density has also been reported to have practical applications in the calculation of thermal properties in heat transfer problems, in determining Reynolds number in pneumatic and hydraulic handling of materials and in predicting physical structure and chemical composition (Irtwange and Igbeka, 2002). The mean values for porosity for the whole seed of SAMNUT 10, SAMNUT 11, and SAMNUT 22 are 0.646, 0.614, and 0.668 respectively, while those for the kernel are 0.373, 0.252, and 0.340 respectively. The surface area for the whole seed was greater than that of the kernel. The surface area is a relevant tool in determining the shape of the seeds. This will actually be an indication of the way the splits will behave on oscillating surfaces during processing (Alonge and Adigun, 1999).

The mean of angle of repose for SAMNUT 10, SAMNUT 11, and SAMNUT 22, whole seed, are 28.180°, 29.273° and 26.947° respectively while that for the kernel are 30.847°, 25.877°, and 24.357° respectively, asides the angle of repose for SAMNUT 10 (kernel) that is greater than the whole seed, the values of kernel for the other varieties are smaller than that of the whole seed. The angle of repose is important for the design of processing, storage, and conveying systems of particulate material. When materials are smooth and rounded, the angle of repose is low. For very fine and sticky materials the angle of repose is high. The angle of repose of any of the varieties can be used in the design of processing and handling equipment. Also, this phenomenon is imperative in the food processing, particularly in the designing of the hopper. Frequency distributions of the various varieties of peanut of both the whole seed and the kernel physical characteristics are shown in Table 1 in terms of skewness. Skewness characterizes the degree of symmetry of a distribution around its mean in a frequency distribution of the measured and calculated physical properties.

Table 1. Frequency distribution of physical properties of the peanut varieties as skewness

S/No	Parameter	SAMNUT 10 (whole seed)	SAMNUT 10 (kernel)	Skewness SAMNUT 11(whole seed)	SAMNUT 11 (kernel)	SAMNUT 22 (whole seed)	SAMNUT 22 (kernel)
1.	D_1	1.447	1.720	0.805	-0.863	1.626	-0.206
2.	D_2	-1.731	-0.878	-0.519	-0.687	-1.028	-0.154
3.	D_3	-1.076	1.279	-1.167	1.214	-1.439	1.490
4.	W_{1000}	-0.888	1.732	1.466	0.514	-0.316	1.265
5.	V	-1.732	0.000	-1.732	0.586	-1.730	0.000
6.	AMD	-1.714	1.446	-0.863	1.727	1.461	-1.495
7.	GMD	0.552	1.306	1.502	1.589	0.473	-0.846
8.	SMD	-0.904	1.358	1.636	1.692	0.980	-1.152
9.	ED	-1.071	1.376	1.468	1.703	1.063	-1.193
10.	S_C	-1.062	-1.283	-1.730	-1.017	0.411	0.050
11.	AR	1.649	0.025	-1.724	-0.599	-0.094	0.749
12.	P_p	0.158	1.732	1.720	-0.037	1.271	1.265
13.	ρ_b	-1.330	0.790	1.462	1.572	-1.729	-0.171
14.	P_f	0.971	0.979	1.731	-0.576	1.482	-0.002
15.	S_a	0.559	1.314	1.485	1.632	0.486	-0.832
16.	Θ_r	2.82E-13	0.536	1.259	1.725	1.662	0.849

Positive skewness indicates a distribution with an asymmetric tail extending towards more value. Negative skewness indicates a distribution with an asymmetric tail extending towards more negative value. Zero value indicates symmetrical distribution.

3.2 Presentation of Results on Mechanical Properties

Fig. 1: Compressive Load against Compression Extension of SAMNUT 10 Unshelled (Area of 4.35 cm^2)

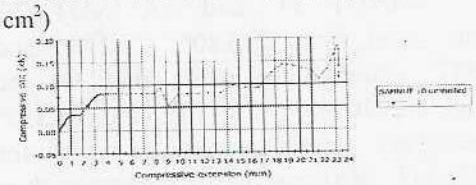


Fig. 2: Compressive Load against Compression Extension of SAMNUT 10 Unshelled (Area of 5.94 cm^2)

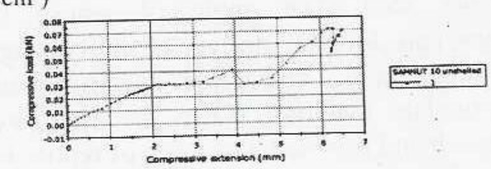


Fig. 3: Compressive Load against Compression Extension of SAMNUT 10 Shelled (Area of 1.91 cm^2)

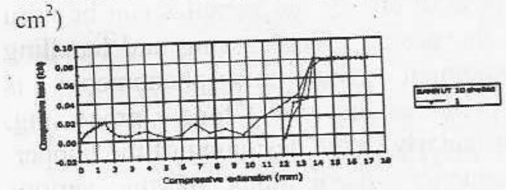


Fig. 4: Compressive Load against Compression Extension of SAMNUT 10 Shelled (Area of 1.96 cm^2)

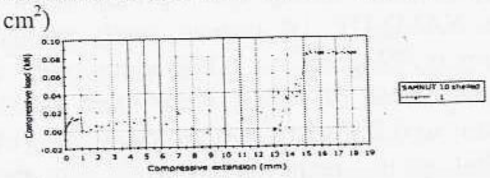


Fig. 5: Compressive Load against Compression Extension of SAMNUT 11 Unshelled (Area of 6.59 cm^2)

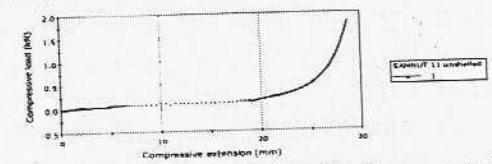


Fig. 6: Compressive Load against Compression Extension of SAMNUT 11 Unshelled (Area of 5.40 cm^2)

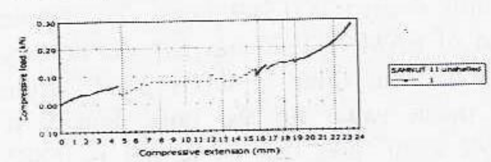


Fig. 7: Compressive Load against Compression Extension of SAMNUT 11 Shelled (Area of 2.11 cm^2)

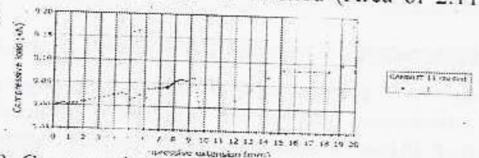


Fig. 8: Compressive Load against Compression Extension of SAMNUT 11 Shelled (Area of 1.85 cm^2)

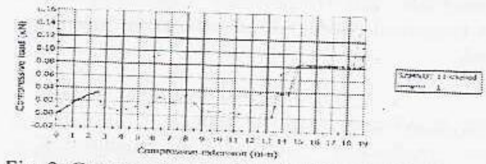


Fig. 9: Compressive Load against Compression Extension of SAMNUT 22 Unshelled (Area of 5.94 cm^2)

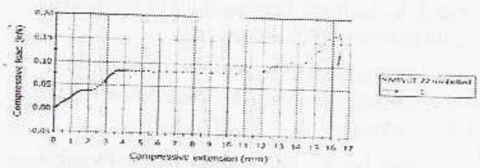


Fig. 10: Compressive Load against Compression Extension of SAMNUT 22 Shelled (Area of 1.57 cm^2)

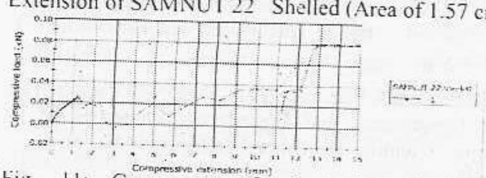
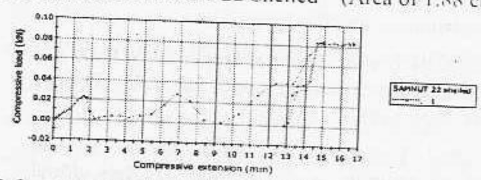


Fig. 11: Compressive Load against Compressive Extension of SAMNUT 22 Shelled (Area of 1.88 cm^2)



3.3. Discussion of Result on Mechanical Properties.

With an anvil height of 7.96 mm set on the Instron universal testing machine. For SAMNUT 10 (Unshelled), the compressive load at break is 115.80 N at compressive extension of 23.23 mm with an area of 4.35 cm^2. Also, with area 5.94 cm^2, the compressive load at break is 69.75 N, at compressive extension of 6.52 mm. For SAMNUT 10 (Shelled), with areas 1.91 cm^2 and 1.96 cm^2, the compressive load at break is 78.83 N, at extension of 14.23 mm, and compressive load of 81.47 N, at extension of 16.03 mm respectively.

For SAMNUT 11 (Unshelled), the compressive load at break is 1811.3 N at compressive extension of 28.69 mm with an area of 6.59 cm^2. Also with area 5.40 cm^2, the compressive load at break is 282.29 N, at extension of 23.38 mm. For SAMNUT 11 (Shelled), with areas 2.11 cm^2 and 1.85 cm^2, the compressive load at break is 88.93 N, at extension of 19.89 mm, and compressive load at break of 82.86 N, at compressive extension of 17.04 mm respectively.

For SAMNNUT 22 (Unshelled), the compressive load at break is 124.53 N, at compressive extension of 16.38 mm with area of 5.94 cm^2. For SAMNUT 22 (Shelled), with areas 1.57 cm^2 and 1.88 cm^2, the compressive load at break is 80.16 N, at extension of 13.87 mm, and compressive load at break of 83.09 N, at compressive extension of 14.93 mm respectively. The probability of fracture of a particle under tension or compression depends on the applied macroscopic stress and the size of the particle. A farm product machine designer needs knowledge of the compressive strength of groundnut for process design and handling. In peanut processing of oil extraction and shelling, the compressive load is an important parameter that must be considered for maximum efficiency of the operations.

4. CONCLUSION

The physical and mechanical properties of three improved varieties of peanut, namely; SAMNUT 10, SAMNUT 11 and SAMNUT 22, of both the whole seed and the kernels including shape, size, geometric mean diameter, sphericity, colour, seed mass, volume, particle density, bulk density, porosity, surface area, angle. of repose, and compressive strength were determined at 7.26%, 7.68%, 7.68%, 6.74%, 6.38% and 6.62% moisture contents for respectively. The dimensions, volumes, mass and surface area of whole seeds were larger than those of kernels. Mass and volume of food materials and agricultural products play an important role in the design of silos and storage bins; determining the purity of seeds; mechanical compressing of ensilages and maturity evaluation. Result showed that the whole seeds had an oblong shape while the kernels had an ovate shape and the bulk densities of both the whole seed and kernels had lesser values than their particle densities. Densities have been of interest in breakage susceptibility and hardness studies. The porosity of the whole seed had higher values than the kernels. The angle of repose of the kernels was lower relative to the whole seed. Typically, the lower the angle of repose of a material, the more flowable the material is. SAMNUT 11 has the highest compressive load while, SAMNUT 10 has the lowest compressive load, for both the whole seeds and the kernels. Knowledge of compressive strength is vital to engineers handling agricultural products. Thus SAMNUT 11 requires a higher force during handling and processing operations involving compression, than SAMNUT 10 and SAMNUT 22.

These parameters are important in designing equipment for handling and processing operations of the product. The statistical analysis shows that there are significant differences between the three varieties. From the data obtained for the selected physical and mechanical properties of peanut, it was established that, they are useful in the design of post harvest handling and processing operations.

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