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Determination of Some Mechanical Properties of Tawain (Hexalobus Crispiflorus) Seed

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Abstract:
The efficient design of agricultural machinery and procedures is critical for food production. Understanding the engineering properties of these materials is vital for engineers and other professionals. The mechanical properties of Tawain (Hexalobus Crispiflorus) seeds are being studied to aid in the design of harvesting, processing, transportation, and storage systems. The axial coefficient of static friction for galvanized steel, plywood, and glass surfaces, as well as compression strength and displacement at fracture at a moisture content of 22% wet basis, are all evaluated in the study. The coefficient of static friction for Tawain seeds on galvanized steel, plywood, and glass surfaces was found to be 0.321, 0.329, and 0.134, respectively. On the transverse axis, the highest applied force and maximum displacement at the cracking of Tawain seeds were 0.42KN, 0.45KN, 0.43KN, 17.04mm, 16.96mm, and 16.67mm, respectively. The maximum applied force and maximum displacement at cracking on the longitudinal axis were 0.34KN, 0.37KN, 0.34KN, 17.75mm, 16.35mm, and 15.24mm, respectively. The data generated from this study can be invaluable for designing systems for handling and processing Tawain seeds, contributing to the efficiency and quality of agricultural processing equipment.

Keywords: Mechanical properties, Tawain, rare wild fruit, handling and processing.

1. INTRODUCTION

Efficiently designing machinery and processes for agricultural material handling and food production necessitates a deep understanding of their engineering properties. These properties are crucial for engineers and have significance in various other fields. Tawain, scientifically known as Hexalobus Crispiflorus, belongs to the Annonacea family and plays a vital role in traditional medicine and local markets. This tree produces edible fruits in regions from Guinea-Bissau to southern Sudan. The fruit of Tawain contains multiple monocarps, making it a valuable dietary resource. In Nigeria, it goes by various names, including "ojiogoda" (Igbo), "apara joke" (Yoruba), and "Tawain" (Izon). Its surface texture ranges from smooth to irregularly ridged, and it serves as a potential source of dietary energy and protein in Nigeria. Understanding the mechanical properties of agricultural products at different moisture levels is crucial for designing machines used in harvesting, cleaning, sorting, handling, and storage. Mechanical properties are essential attributes affecting the processing and handling of seeds, making them vital for designing agricultural processing equipment. This study aims to determine the specific mechanical properties of Tawain (Hexalobus Crispiflorus) seeds.

This study provides valuable engineering data, including compressive strength, displacement, and frictional coefficient, which are crucial for designing machines, storage structures, and quality control processes for Tawain seeds on various surfaces such as plywood, galvanized steel, and glass. These findings contribute to the efficient handling and processing of agricultural materials. This study faced limitations such as time constraints, strikes affecting the research pace, and challenges accessing practical equipment and laboratory facilities. This research focuses primarily on specific mechanical properties of Tawain seeds, precisely compressive strength, fracture displacement, friction coefficient, and moisture content. Tawain (Hexalobus Crispiflorus) is a versatile tree with economic significance, primarily found in dense, humid forests. Its wood is used in construction and various applications, and its fruits have nutritional and medicinal value. Additionally, the bark of Tawain has the potential for drug development. Studies on various agricultural products' physical and mechanical properties have contributed to the design of equipment for processing, transportation, sorting, and separation. These properties include coefficient of friction, compressive strength, and other mechanical attributes. Agricultural materials undergo multiple unit operations from pre-harvest to post-harvest processing, formulation, preservation, packaging, storage, distribution, and consumption.

Understanding the engineering properties of these materials is crucial for designing equipment and processes in agriculture. Mechanical properties are vital in designing processing and handling machinery for agricultural products. These properties encompass force, direction, stress, strain, hardness, and compressive strength. Moisture content significantly influences these mechanical properties, making it a critical factor in designing efficient equipment. Friction is a critical phenomenon in the interaction between materials. The coefficient of static friction is essential for understanding how agricultural products interact with different surfaces. It impacts the performance of conveying, separating, cleaning, drying, and storing equipment.

Information on mechanical properties of grains could help food industries obtain products with better functional, nutritional and sensory qualities with greater cost benefits. To make superior nutritional value and yield products particularly rely on the in-depth knowledge of the engineering properties. Engineering properties of biological materials such as tawain seed have unique characteristics which set them apart from other engineering materials. The irregular shape of most agricultural materials complicates the analysis of their behaviour. Also due to the increasing importance of agricultural products together with the complexity of modern technology for their production, processing and storage, a better knowledge of their engineering properties is necessary. This research focuses primarily on specific mechanical properties of Tawain seeds, precisely compressive strength, fracture displacement, friction coefficient, and moisture content.

2. MATERIALS AND METHODS

This work is based on the determination of some mechanical properties of Tawain seed. These properties include; compressive strength, displacement at fracture and frictional coefficient on three different structural surfaces (galvanized steel, plywood and glass).

2.1 Selection of materials

Tawain seeds used in this study were harvested in Yenagoa market, Bayelsa state, Niger delta, Nigeria during the fruiting season (August-September 2018). About 50 fruits were harvested for this experiment. The seeds were extracted, cleaned, and sorted to remove foreign materials, and infested and immature seeds. Cleaned seeds were then stored at room temperature and used after one month of harvest.

2.2 Determination of some mechanical properties

The mechanical properties that were considered in this study are compressive strength, displacement, and coefficient of static friction. The mechanical properties were determined on moisture content 12% (wet basis. 2.2.3)

2.2.1 Determination of compressive strength and displacement

The universal testing machine (GUNT HAMBURG, w300) was used to obtain the maximum compression force required to crack the seed and the displacement the seed experiences before cracking. In order to perform each test, the seed to be tested is placed on its transverse side between the upper and lower jaw of the universal testing machine. The hydraulic wheel that operates the movement of the upper jaw was turned to lower the upper jaw until it just touched the tawain seed and held it in position without compressing it. The force display that measures the applied force and the displacement meter were both turned to zero. Then the hydraulic wheel was turned to give the upper jaw a slow and steady downward motion compressing the tawain seed. The upper jaw was lowered until a cracking sound was heard. The lowering of the upper jaw was then immediately stopped and the force was read from the force display while the displacement was read from the displacement dial gauge meter and recorded in figure (2 and 3).

2.2.2 Determination of coefficient of static friction

Static coefficient for Tawain seed was determined using a tilting plane mechanism with respect to three surfaces: plywood, galvanized iron, and glass with the seed parallel to the flow direction. A tilting plane was used to determine the coefficient of friction. Thus fifty (50) were randomly selected and used for the friction test. During each test, the flat iron plate was first cleaned with a smooth sand paper (GXK51-LD P 240) to remove any surface contamination before a seed was placed on the surface. The tilting rope was pulled gradually to raise the tilting plane until the seed started sliding or rolling down the plane. The pulling of the rope was then stopped and the angle of inclination (angle of repose of the tilting iron plate was read from the protractor and recorded, same process was repeated for plywood and glass surfaces. The coefficient of friction was calculated using the equation below;

u= tan A

Where u is static coefficient of friction

© is the angle from the horizontal plane

2.2.3 Determination of moisture content

Moisture content was determined by oven drying the samples at temperature of 100 °c for 6 hours adopted from Olaoye (2002) and Ozguven et al, (2005) for castor nut and pine nuts respectively. This method was chosen since there is no approved method for determining the moisture content of this type of the seed material. The moisture content (wet basis) of the seed was determined by the relationship.

% moisture content = M1 - M2 × 100 wet basis

Where; MI - initial weight of sample

M2 - final weight of the sample

3. RESULT AND DISCUSSION

This analysis presents the results of the mechanical property tests conducted on Tawain seeds. The coefficient of static friction, compressive strength, and displacement at fracture were determined, and the findings are discussed. In determining some of the mechanical properties of Tawain seed, moisture, a reading 22% wet basis was selected, and the mechanical properties at this moisture content level of the source were conducted. The results are as represented.

3.1 The coefficient of static friction

This was determined concerning three structural surfaces (galvanised, plywood, and glass) and the experiment was conducted to show how Tawain seed at 22% moisture content wet basis will slide on these surfaces. From the result, the coefficient of static friction was higher in plywood, followed by galvanized steel and then glass, as shown in figure 1. Due to the material surface, the average coefficient of static friction between the Tawain seed and galvanized steel, plywood, and glass surfaces are 0.321, 0.329, and 0.134. This parameter is essential in designing the hopper design, especially a tawain peeling machine. The design of a hopper made from stainless steel requires a smaller cone slope so that for the same hopper volume, the height of the stainless-steel cone hopper can be designed lower. This parameter is crucial in understanding how Tawain seeds interact with surfaces during storage and handling. A higher coefficient of static friction suggests that Tawain seeds may tend to stick or resist movement on certain surfaces. This finding is vital for designing equipment that ensures smooth and efficient seed flow during processing and transportation. The coefficient of friction between seed and surface is an important parameter in the prediction of seed pressure on wall. This phenomenon is imperative in food grain processing, particularly in the designing of hopper for milling equipment. The angle of repose will determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. To ensure free flow, an angle of repose which is modestly higher than the average angle of repose. The knowledge of the coefficient of friction will be useful during the calculations of the various forces required to translate, compress and crush the seeds as well as the frictional force resulting from the motion of the screw and grinding discs. Therefore, the exact determination of friction coefficients of the crop in different contact surfaces is helpful in the optimization of mechanical equipment (conveyors, separation, cleaning, drying and storing tools), and consequently, reduction and increment of harmful damages and economic efficiency.

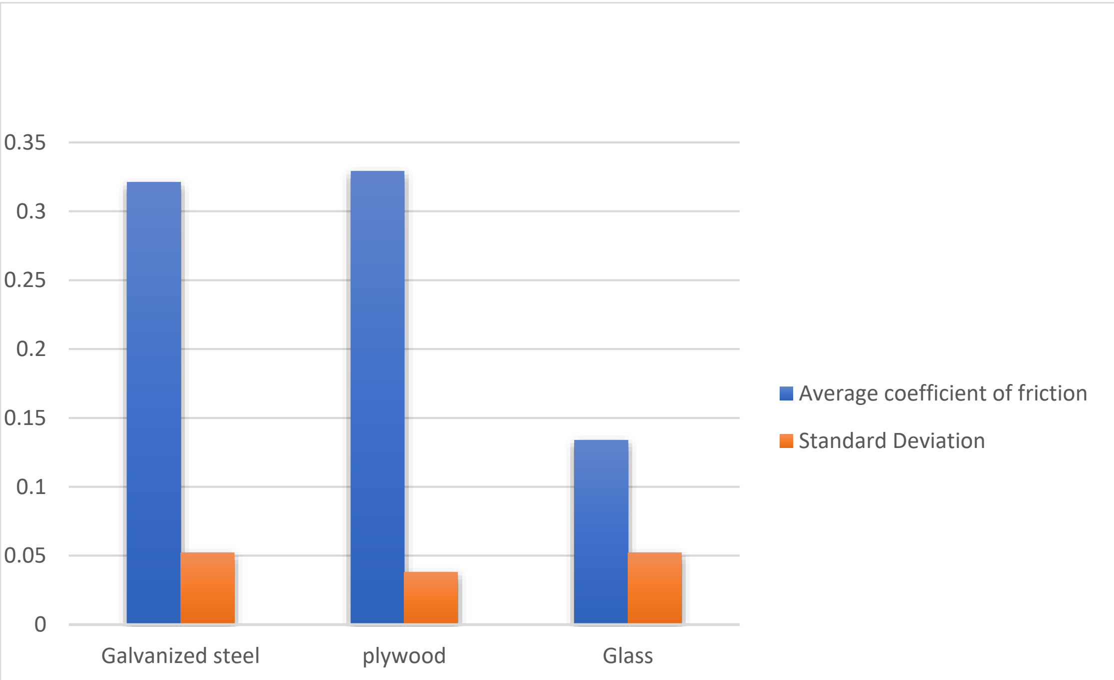

Figure 1: Summary of the Coefficient of friction *tawain* seed and three different surfaces

3.2 Force and displacement

The results of maximum forces and maximum displacement experienced by the tawain seed at the point for cracking are shown in figures 2 and 3. These properties were carried out on both longitudinal and transverse axes. The results show that the forces required for cracking the different sizes of tawain seed are close to each other, On the other hand, the maximum displacement experienced by the tawain source at the point of cracking differs the - biggest for the smallest grains seeds and smaller most significant size of seeds. However, the seed will crack the root never a tawain seed is compressed on its transverse side and attains the displacement shown in figures 2 and 3 the seed will crack.

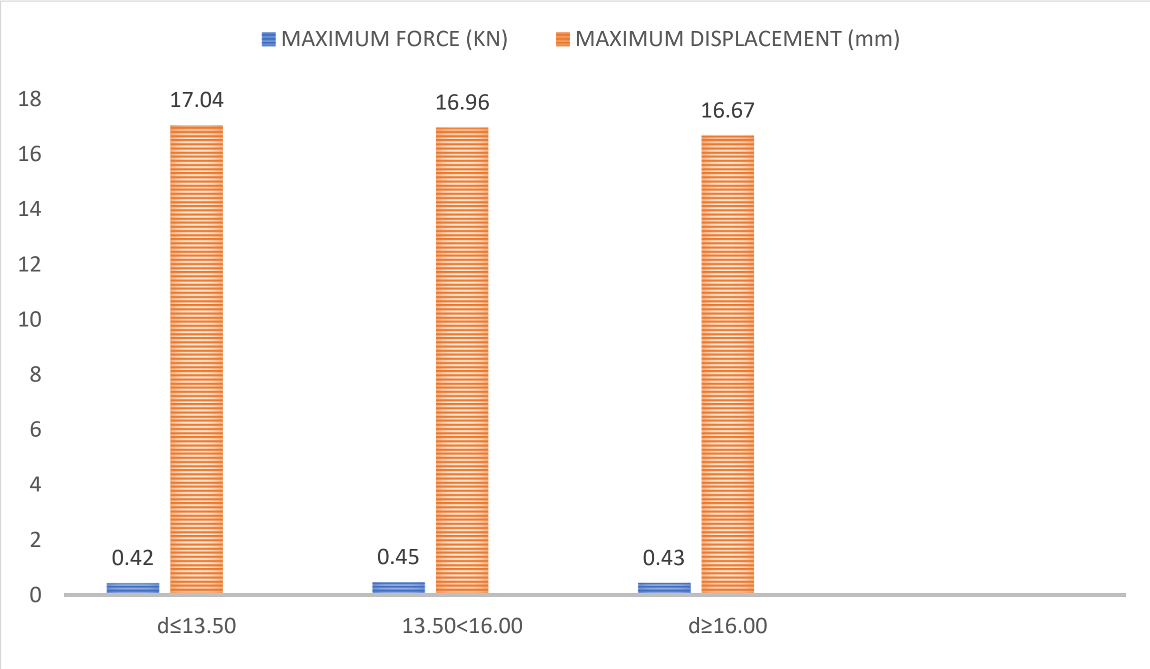

Figure 2: Summary maximum applied force and maximum displacement at cracking of the tawain seed on transverse axis

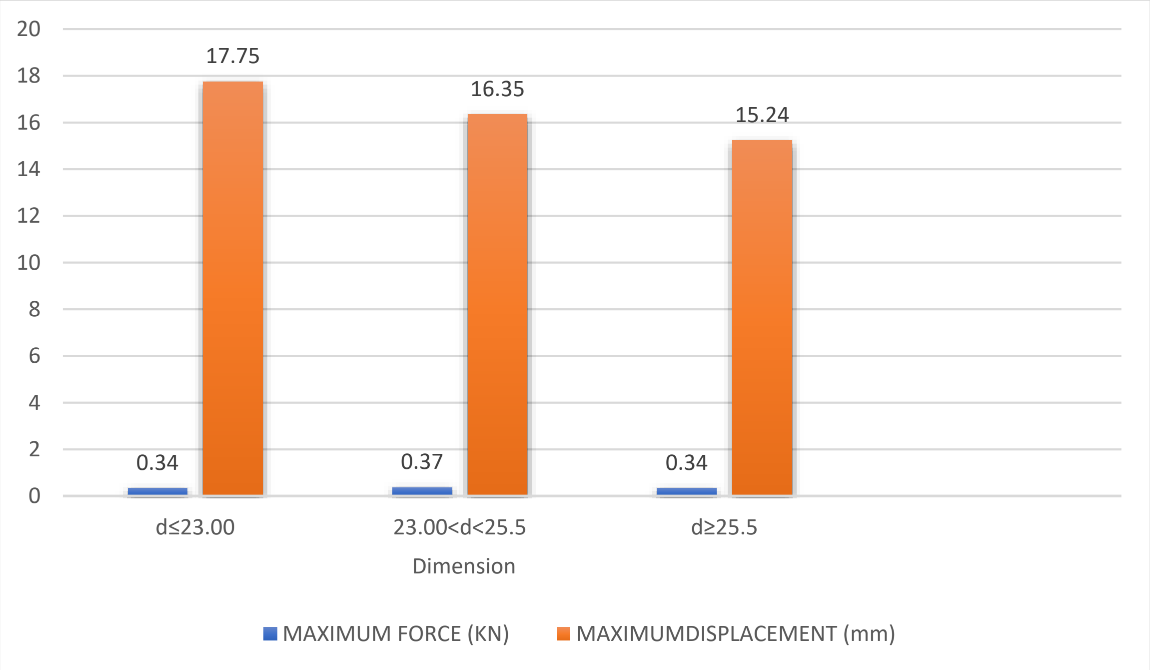

Figure 3: Summary of the maximum applied force and maximum displacement at cracking of the tawain seed on longitudinal axis

3.2.1 Compressive Strength: The maximum applied force required to crack Tawain seeds on the transverse and longitudinal axes was measured. The values obtained were 0.42KN, 0.45KN, 0.43KN for the transverse axis and 0.34KN, 0.37KN, 0.34KN for the longitudinal axis. The toughness of the samples was found to be higher at transverse loading position. The study also provided insights into the compressive strength of Tawain seeds. Compressive strength is a fundamental mechanical property that indicates the seed's ability to withstand crushing forces. Knowledge of this property is indispensable for designing equipment that exerts controlled pressure during oil extraction or milling processes. Optimizing equipment based on compressive strength data can help prevent seed damage and improve overall processing efficiency. The minimum hardness was parallel to the longitudinal axis. Regarding this compressive strength, it is a very important parameter in the development of an optimal mechanical peeler or cracking equipment, especially with the selection of an electric motor. Designs which do not take these parameters into account may not be optimal, i.e., may have inadequate power or maybe over-designed, i.e., too much power, which results in wasting money. This issue needs to be avoided so that the design of the tool/machine is fit and proper in terms of its function and price. To be even more optimal, it is also necessary to consider the tawain orientation during the peeling process, in which the cutting knife needs to be forced into cutting in the direction of orientation so that the design of the tawain shell peeler uses the least engine power.

3.2.2 Displacement at Fracture: The maximum displacement at cracking for Tawain seeds on both axes was measured, with values of 17.04mm, 16.96mm, 16.67mm for the transverse axis and 17.75mm, 16.35mm, 15.24mm for the longitudinal axis. The discussion provides insights into the implications of these findings for equipment design and seed handling. Understanding the removal at the fracture point of Tawain seeds is critical for equipment design, especially for processes involving mechanical stress. This parameter helps determine the seed's structural integrity and resilience. Designing equipment with this knowledge can minimize seed breakage, which is essential for preserving seed quality and ensuring higher yields during processing.

4. CONCLUSSIONS

The study recommends further research in the following areas; Investigation of the Effect of Moisture Content on Mechanical Properties, Future research should focus on examining how varying moisture content affects the mechanical properties of Tawain seeds. This will help understand the seed's behaviour under different environmental conditions and aid in optimizing storage and processing methods.

Development of Equipment and Processes Tailored to Tawain Seed Handling: Specialized equipment and processing methods are needed to improve the efficiency and quality of handling Tawain seeds. Research should be conducted to design machinery and techniques specifically adapted to Tawain seeds' characteristics. This can enhance seed processing, reduce losses, and improve overall seed utilization.

Study of the Nutritional and Medicinal Properties of Tawain Seeds for Potential Value Addition: Investigating the nutritional and medicinal properties of Tawain seeds can lead to value addition and diversification of their use. Further research is needed to explore the bioactive compounds, nutritional content, and potential health benefits of Tawain seeds. This information can open opportunities for developing functional foods, nutraceuticals, or pharmaceutical products.

References:

Arun, A.P., K.Seeniappan, L.Natrayan, ad P.P.Patil. 2022. Mechanical, fracture toughness, and dynamic mechanical properties of twill weaved bamboofibre-reinforced Artocarpus heterophyllus seed husk biochar epoxy composite.

Bamgboye, A.I. and Adejumo, O.I. (2009). Physical Properties of Roselle (Hibiscus Sabdariffa L.) seed. Agricultural Engineering International: the CIGR Ejournal, 11.

Baryeh, E.A. (2002). Physical properties of millet. Journal of Food Engineering, 51(1), 39-46.

Chukwu, O. and Sunmonu, M.O. (2010). Determination of Selected Engineering Properties of Cowpea (Vigna unguiculata). Related to Design of Processing Machines. International Journal of Engineering and Technology, 2(6), 373-378.

Dauda, S.M., Ahmad, D., Khalina, A. and Jamarei, O. (2014). Physical and mechanical properties of kenaf stems at varying moisture contents. Agriculture and Agricultural Science Procedia, 2, 370-374

Dauda, S.M., Ahmad, D., Khalina, A. and Jamarei, O. (2015). Effect of cutting speed on cutting torque and cutting power of varying kenaf-stem diameters at different moisture contents. Pertanika Journal of Tropical Agricultural Science, 38(4), 549-561.

Fabunmi, O.A., Omeiza, U. and Alabadan, B.A. (2015). Physical and Mechanical Properties of Raphia (Raphia farinifera) Seed essential for handling and processing operation. Proceedings of the first International Engineering Conference (IEC), p. 61- 70. Nigeria: Federal University of Technology

Idama, O., H. Uguru, and O. Akpokodje. 2021. Mechanical properties of bell pepper fruits, as related to the development of its harvesting robot.

Jeeva, B., K.R.R. Khishorre, and P.Rahul. 2023. Mechanical seed implanter for sunflower and groundnut seeds: design and fabrication.

K. D. Astanakulov, A.D.Rasulove, K.A. Baimakhanov, Kh.M. Eshankulov, and A.J, Kurbanov. 2021. Important physical and mechanical properties of the mung bean seed for harvesting and cleaning process.

Kilanko O., Ojolo S.J., Leramo R.O., Ilori T.A., Oyedepo S.O., Babalola P.O., Fayomi O.S., Onwordi P.N., Ufot E., Ekwere A. 2020. Dataset on physical properties of raw and roasted cashew nuts.

Koocheki, A., Razavi, S.M.A., Milani, E., Moghadam, T.M., Abedini, M., Alamatiyan, S. and Izadkhah, S. (2007). Physical Properties of Watermelon seed as a function of moisture content and Variety.

Mohammed, A., Balami, A.A., Dauda, S.M., Mohammed, I.S. and Abdulfatai, Y. (2017). Engineering properties of luffa (L. cylindrica) seed relevant to the processing machineries. Agricultural Engineering International: CIGR Journal, 19(3), 47 -55.

Malik, M. A., and C. S. Saini. 2016. Engineering properties of sunflower seed: Effect of dehulling and moisture content. Cogent Food and Agriculture, 2(1): 1145783.

Mohite, A. M., N. Sharma, and A. Mishra. 2019. Influence of different moisture content on engineering properties of tamarind seed. CIGR Journal, 21(1): 220-224.

Olajide, J.O. and Igbeka, J.C. (2003). Some Physical Properties of Groundnut Kernels. Journal of Food Engineering, 58(2), 201-204.

Oduma, O., O. O. Onu, and J. E. Igwe. 2016. Effect of moisture content on some physical and mechanical properties of an African oil bean seed (Pentechletra Macrophylla). Umudike Journal of Engineering and Technology, 2(2): 78-85.

Onwe, D. N., K. C. Umani, W. A. Olosunde, and I. S. Ossom. 2020. Comparative analysis of moisture-dependent physical and mechanical properties of two varieties of African star apple (Chrysophyllum albidum) seeds relevant in engineering design. Scientific African, 8: e00303.

Olakunle, O., E.I.Alade, and S. Oyelami. 2023. Effect of moisture contents and compression axes on some physical and mechanical properties of dioclea reflexa seed.

Pragalyaashree, M. M., Kailappan, R., & Kennedy, Z. John (2003). Mechanical properties of onion seeds (Allium cepa variety aggregatum 'L.') under compression loading.

Togo, J. M., D. Wang, W. Ma, and C. He. 2018. Effect of moisture content on selected physical and mechanical properties of alfalfa seeds. Journal of Biology, Agriculture and Healthcare, 8(14): 8-18.

Tunde-Akintunde, T. Y., B. O. Akintunde, and O. J. Oyelade. 2007. Effect of moisture content on terminal velocity, compressive force and frictional properties of melon seeds. CIGR Journal, 7: Manuscript FP 07 022

Tarighi, J., Mahmaudi, A., & Alavi, N. (2016). Some mechanical and physical properties of corn seed.

Wandkar, S. V., P. D. Ukey, and D. A. Pawar. 2012. Determination of physical properties of soybean at different moisture levels. CIGR Journal, 14(2): 138-142

Zareiforoush, H., S.S. Mohtasebi, H. Tavakoli, and M.R. Alizadeh. 2010. Effect of loading rate on mechanical properties of rice (Oryza sativa L) straw.