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Determination of Selected Engineering Properties of Jathropha Seed

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Abstract:** Jatropha (Jatropha curcas L.) is a prominent renewable energy plant with great potential for biodiesel production from its seeds. This research project aimed to investigate the engineering properties of Jatropha seeds to evaluate their suitability for biodiesel production and various industrial applications. By reducing reliance on fossil diesel, Jatropha biodiesel offers the prospect of enhanced energy security and reduced environmental pollution resulting from fossil fuel combustion (Werby and Mousa, 2016). The study focused on understanding the physical, mechanical, and aerodynamic properties of Jatropha seeds. Knowledge of these properties is crucial for the design of efficient machines and equipment used in processing, handling, cleaning, transporting, and storage of agricultural products like Jatropha seeds. Specifically, the research investigated the physical characteristics of the seeds, including size, shape, color, and texture. Moisture content was analyzed using standard drying methods, while bulk density and true density were measured through displacement techniques. Results indicated that Jatropha seeds possess favorable physical properties for handling and processing. In conclusion, this research contributes valuable insights into the engineering properties of Jatropha seeds, making them a promising bioresource for biodiesel production and diverse industrial applications. Addressing the identified challenges can further enhance their potential utilization and contribute to sustainable energy practices.

Keywords:** Jatropha, Biodiesel, Renewable Energy, Engineering Properties, Physical Properties, Mechanical Properties, Aerodynamic Properties.

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1. INTRODUCTION

Jatropha, one of the renewable energy plants, has the potential to produce biodiesel fuel from its seeds, reducing dependence on fossil diesel and enhancing energy security while mitigating environmental pollution from fossil fuel combustion (Werby and Mousa, 2016). For successful utilization of jatropha as a biofuel, understanding the physical, mechanical, and aerodynamic properties of agricultural products is crucial in designing different machine components for processing, handling, cleaning, transporting, and storage, as highlighted by Awady and El-Sayed (1994), EL-Raie et al. (1996), Tayle et al. (2011), and Werby and Mousa (2016).

In response to environmental concerns and the need to reduce reliance on fossil fuels, many countries have prioritized replenishing fossil fuel demand with renewable sources. Jatropha has been considered a promising biofuel candidate; however, most claims of its potential lack scientific and technological backing. Consequently, there has been limited progress, and jatropha has not significantly contributed to the energy scenario. The main reasons for this lack of success include the absence of high yielding cultivars, large-scale plantation without proper evaluation of the planting material, and gaps in knowledge and basic research.

This study aims to address the challenges facing jatropha production as a biofuel, including issues related to production, oil extraction, conversion, and its overall sustainable use. The primary focus is on determining the engineering properties of jatropha seeds.s

Aim

The main aim of this project work is to determine physical engineering properties of jatropha seed

Objectives

i. to determine the physical properties of jatropha seed
ii. to analyze the physical properties using Analysis of Variance (ANOVA)

Justification

The result from this study work will assist farmers, researchers and processors in improving and developing new device (machine) in the following unit post-harvest operation of jatropha seed harvesting, handling, shelling and storage.

Scope of the Study

The scope of this study deals mainly with physical engineering properties (shape, size, density, sphericity, surface area).

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2. MATERIALS AND METHODS

Sourcing of the Experimental Material

Jatropha curcass seeds were purchased at Sango market, Kwara State, and stored in a cool, dry place before conducting the experiments. All experiments to determine the physical properties took place in the crop processing laboratory of the Department of Agricultural and Bio Environmental Engineering Technology at the Institute of Technology, Kwara State Polytechnic, Ilorin, within the normal room temperature range.

Determinations of Physical Properties

The physical properties were determined as follows: size, shape, sphericity, geometric mean, arithmetic mean, and surface area. For each of the four fractions, samples of one hundred seeds and one hundred kernels were taken, and the experiments were repeated in five replicates. The unit mass (m) in grams was recorded using an experimental balance (Sartorius Basic) with an accuracy of ±0.001g. To measure the geometrical dimensions of J. curcas seeds and kernels, the length (x), width (y), and breadth (z) were assessed using a digital Vernier calliper (Mitutoyo, Japan) with an accuracy of ±0.01mm. The arithmetic mean diameter (Da) and geometric mean diameter (Dg) of the seeds and kernels were then calculated from these geometrical dimensions according to the formulas provided by Mohsenin (1980) and Bahnasawy (2007).

Da = (x + y + z)/3andDg = (x · y · z)1/3

Sphericity, - of seeds and kernels was calculated based on the isoperimetric property of a sphere (Mohsenin, 1980): (x · y · z) 1/3 x = Dg x

Determination of Mass

The mass of jatropha was determined by using asensitiveelectrical weighing scale with accuracy of 0.001g.A 100 pieces of jatropha seeds were randomly selected and placed on the analog weighing scale and recorded carefully.

Determination of Size and Shape

Thethree axial dimensions that is length, width and thickness were measured using a verniercaliper (reading up to 0.1mm). The geometric mean diameter (Dm) in mm was computed from the value obtained for the dimensions of the jatropha seeds using the following formula given by (fadele et al 2011).

$Dm_{=}(abc)^{1/3}$

Where;

a₌the length of the dimension along the longest axis is mm

b₌ the width of the dimension along longest axis perpendicular to a in mm

c₌ the thickness, is the dimension along the longest axis perpendicular to both a and b in mm.

Sphericity

This is a criterion that is used to describe the shape of fruit. According to Mohsenin (1970), sphericity Φ was calculated using the formula

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$\Phi = \frac{(abc)^{1/3}}{a}$ (Ayobamidele and Manuwa, 2011)

Geometric Mean Diameter
The geometric mean of the seeds was calculated using the following equation.
$Dg = (lwt)^{1/3}$ (Baryehet al, 2002)
Where;
$Dg =$ the geometric mean diameter
$L =$ the length or major diameter
$W =$ the width or intermediate diameter
$T =$ the thickness or minor diameter

Surface Area
The surface area was determined using this equation (Mccabe et al., 2006)
$S = \prod Dg^2$
Where $\prod =$ pie (3.142)
$Dg =$ the geometric mean diameter of the seeds

Instruments
The following instruments was used for the study:

i. **Vernier Caliper:** for measuring the three axial dimensions of jatropha seeds. A carbon Fiber composite Digital Caliper with resolution, accuracy and battery of± 0.1mm/0.01, and SR44/LR44 1.5V respectively was used for the study.
ii. **Digital Weighing Scale:** for measuring the mass of jatropha seeds. An electronic digitalweighing scale with model number WH-B05 was used for the study. Its resolution and accuracy are 0.1g and± 0.1g respectively.
iii. **Measuring Cylinder:** for measuring the volume of jatropha seeds.

Plate 1: Moisture Analyzer

Plate 2: Vernier Caliper

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Plate 3: Measuring Cylinder


Plate 4: Digital Weighing Scale

Statistical Analysis
Analysis of variance (ANOVA) was used to analyze the physical engineering properties of Jatropha seed using SPSS 22.0 version statistical package.Analysis of Variance (ANOVA) is a statistical formula used to compare variances across the means (or average) of different groups. A range of scenarios use it to determine if there is any difference between the means of different groups. The results were display in chapter to know the effect of the various physical properties.

3. RESULTS AND DISCUSSION

Determination of Physical Engineering Properties

Table 4.1: Average Physical Engineering Properties

S/No	Length	Width	Breadth	Gm	Am	SFA	SPH
1	18.37	10.875	8.54	13.38206	12.53664	663.0276	4.41037
2	18.27	10.78	8.995	12.08881	12.67915	459.5703	2.22234
3	18.15	10.5	8.9	6.935	12.315	208.15	4.5005
4	18.485	11.015	9.35	13.25672	12.96055	437.9776	4.677325
5	18.285	10.615	9.015	136.2609	12.60445	115172.7	3.77942

Effect of Physical Engineering Properties

Table 4.2: Descriptive statistics of Physical Properties of Jatropha Seed

	N	Mean	Std. Deviation	Std. Error Mean
Length	5	18.3120	0.12453	0.05569
Widgth	5	10.7570	0.20447	0.09144
Breagth	5	8.9600	0.28998	0.12968
Geometric	5	36.3847	55.89467	24.99686
Arithmetic	5	12.6192	0.23435	0.10481
SFA	5	23388.2838	51309.29791	22946.21560
SPH	5	3.9180	1.00658	.45015

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Table 4.3: Analysis of variance for Jatropha Seed

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Length	328.814	4	.000	18.31200	18.1574	18.4666
Widgth	117.638	4	.000	10.75700	10.5031	11.0109
Breagth	69.092	4	.000	8.96000	8.5999	9.3201
Geometric	1.456	4	.219	36.38470	-33.0177	105.7871
Arithmetic	120.405	4	.000	12.61916	12.3282	12.9101
SFA	1.019	4	.366	23388.28383	-40320.6242	87097.1918
SPH	8.704	4	.001	3.91799	2.6682	5.1678

4. DISCUSSION

Table 4.1 above shows the average physical engineering properties of jatropha seed while table 4.2 shows descriptive statistics of physical properties of Jatropha Seed and table 4.3 shows analysis of variance. From table 4.3, it can be observed that the length, the width, the breadth, the arithmetic mean and the sphericity were highly significant because they have 0.000 and 0.001 which is less than percentage value of 0.05 (p-value <0.05) standard. This implies that the length, the width, the breadth, the arithmetic mean and the sphericityhas influence on the jatropha seed.

5. CONCLUSION

In conclusion, the physical properties of jatropha seeds play a crucial role in determining various aspects of their utilization and potential applications. The size and weight of the seeds directly impact the ease of handling during harvesting and processing. Larger and heavier seeds may provide higher yields and oil content, making them more desirable for biodiesel production. The seed moisture content is a critical factor affecting storage and germination. Proper drying and storage techniques are essential to maintain seed viability and prevent spoilage during storage. Additionally, the moisture content can influence the oil extraction efficiency, with lower moisture content generally leading to higher oil yields. The hardness and shell thickness of jatropha seeds influence the ease of oil extraction. Seeds with thicker shells may require more energy and specialized equipment for efficient oil extraction. Research and development of improved extraction methods are necessary to make the process more cost-effective and sustainable. Furthermore, understanding the seed morphology, such as the seed coat structure, is crucial for developing effective pretreatment methods to enhance oil extraction. Seed coat characteristics may also impact the seed's resistance to pests and diseases, which can have significant implications for jatropha cultivation. Overall, the physical properties of jatropha seeds are closely linked to their agricultural and industrial potential. As the demand for sustainable energy sources continues to grow, further research into enhancing seed properties and developing innovative processing techniques will be vital

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to unlock the full potential of jatropha as a renewable energy resource. Moreover, sustainable cultivation practices that focus on improving seed quality will play a pivotal role in maximizing the economic and environmental benefits of jatropha production in the future.

Recommendation

Based on the analysis of the effect of physical properties on jatropha seeds, several recommendations can be made to optimize their utilization and potential applications:

i. **Genetic Improvement**: Invest in research and breeding programs aimed at developing jatropha varieties with desirable physical properties. Selective breeding can target larger and heavier seeds with thinner shells and higher oil content, making them more suitable for biodiesel production and reducing the energy requirements for oil extraction.

ii. **Optimize Harvesting and Post-Harvest Handling**: Implement efficient harvesting techniques to minimize damage to the seeds and prevent premature shattering. Proper post-harvest handling, including timely drying to reduce seed moisture content, will ensure better seed quality, storage, and germination rates.

iii. **Innovative Extraction Methods**: Invest in the development of novel and sustainable oil extraction techniques that can efficiently process jatropha seeds with varying physical properties. Consider exploring techniques like pre-treatment methods to weaken seed shells and facilitate oil release, ultimately enhancing the overall oil extraction efficiency.

iv. **Seed Storage and Viability**: Enhance seed storage practices to maintain seed viability over extended periods. Implement controlled environments and appropriate storage conditions to prevent deterioration and preserve seed quality for subsequent cultivation.

v. **Disease and Pest Resistance**: Investigate the link between seed physical properties, such as seed coat characteristics, and resistance to pests and diseases. Develop disease-resistant seed varieties and promote integrated pest management practices to protect jatropha crops from potential threats.

vi. **Education and Awareness**: Educate farmers and stakeholders about the importance of seed physical properties and their impact on crop performance. Raising awareness of best practices related to jatropha seed selection, handling, and processing will contribute to improved overall crop yield and economic outcomes.

vii. **Sustainable Cultivation Practices**: Encourage sustainable farming methods, including crop rotation and intercropping, to promote soil health and reduce pest pressure. Sustainable practices can lead to improved seed quality and higher yields over the long term.

viii. **Collaboration and Research**: Foster collaboration between researchers, agronomists, and industry stakeholders to share knowledge, exchange ideas, and collectively address challenges related to jatropha seed physical properties. Increased research and development efforts will lead to more efficient and sustainable jatropha production.

By implementing the above recommendations, it is possible to optimize the physical properties of jatropha seeds and unlock the full potential of this plant as a valuable renewable energy resource, while also promoting its application in various other industries. Moreover, a focus on sustainable practices will contribute to the environmental and socio-economic benefits of jatropha cultivation.

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