The Influence of Moisture Content on the Physical Properties of Cowpea (*Vigna Unguiculata*)

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Abstract

The purpose of this study was to assess how moisture content affected the physical characteristics of cowpea (Vigna unguiculata) on both a dry and wet basis. Length, width, thickness, geometric diameter, and arithmetic diameter are the physical attributes that are examined for both wet and dry bases. Both values of wet and dry samples physical characteristics such as length, width, thickness, geometric diameter were affected by moisture content but, dry samples were recorded with greater values. The experiment's findings indicate that, with the exception of angle of repose, where the wet basis is greater than the dry basis, the dry sample's values increased for geometric diameter, arithmetic diameter, sphericity, aspect ratio, surface area, and coefficient of friction. Moisture contents and other physical properties like angle of repose, porosity, friction, etc., of the selected sample were measured and then recorded. According to the experimental study, the physical characteristics of cowpea seeds decrease with increasing moisture content. These characteristics are crucial when designing the right machinery for the processes of harvesting, processing, transporting, separating, packing, and storing. Poor cowpea mechanization in Nigeria has been noted to be caused by a lack of handling equipment since agricultural products' physical characteristics vary widely. Physical characteristics of the crop are required in order to develop a working equipment for crop mechanization.

Keywords: Angle of repose, Arithmetic diameter, Coefficient of friction, Surface area.

Introduction

The cowpea, or *Vigna unguiculata*, is a significant grass legume and a food item that is primarily consumed in developing nations. Both humans and animals can benefit from its high protein content (Tarawali et al., 1997; Singh, 1999). According to Aremu et al. (2007), cowpea seeds have one of the highest protein contents of any cultivated legume. Millions of people in Africa and other developing nations depend on cowpeas for their daily sustenance. They are a valuable and reliable commodity that generates revenue for farmers and traders, and they are a significant source of dietary protein that nutritionally complements staple low-protein cereals and tuber crops (Singh, 2002). The impact of moisture content on cowpea's physical characteristics was ascertained in this investigation. It was also examined how the moisture content affected the cowpea's porosity, angle of repose, coefficient of friction, sphericity, and surface area.
A quarter of protein and a number of vitamins and minerals can be found in cowpeas. Because they are legumes, the plants thrive in a variety of soil types, can withstand drought, and replenish low-fertility soil when their roots are allowed to decompose. Due to its tolerance for shade, it is mostly farmed by small-scale farmers in underdeveloped nations, where it is frequently grown alongside other crops. In order to stop erosion, it also spreads and covers the ground rapidly (Dugje et al 2009). Nigeria is the world's greatest producer of cowpeas, claims Henshaw (2008). While the grain is used to make a variety of snacks and main meal meals, the young leaves, immature pods, and seed are utilized as vegetables while they are fresh. Additionally, 50% to 67% of the cowpea grain is starch. It is arguable that cowpeas can be grown in semiarid regions, particularly in West and Central Africa (Singh 1997). According to Davies and Zimbokere (2011), cowpeas are extremely high in protein, water, ash, lipids, and carbohydrates, with respective contents of roughly 23.4%, 11%, 3.6%, 1.3%, and 5.6%. Every physical characteristic of these seeds varies, including the texture of the seed coat and the color of the hilum. Bean seeds can be globose, ovoid, or rhomboid in shape, in contrast to the usual kidney shape (Henshaw, 2008).
When it comes to grain processing, moisture is a crucial crop element. It significantly affects the degree of mechanical damage sustained during harvesting and threshing operations, grain flow on the surface during transportation, air separation during cleaning and sorting operations, processing machine efficiency and storage, and many other operations. Therefore, understanding how cowpeas behave in terms of their physical characteristics and different moisture levels is crucial. Physical characteristics play a significant role in resolving issues pertaining to the design of particular machinery or the analysis of product behavior during agricultural processes, such as planting, harvesting, handling, threshing, sorting, and drying. Understanding the engineering and physical characteristics of items is necessary to solve this issue (Irtwange & Ugbeka, 2003). Machines used for harvesting, sorting, washing, handling, and storing agricultural resources require information about their physical and simplified characteristics, such as their size. Size and shape are two of the most crucial geometric characteristics taken into account when cowpea is separated and cleaned. Because of their uneven forms, agricultural seeds are

supposed to be elliptical or spheres in theoretical calculations (Mohsenin, 1980). Given that they are consumed in all 10 regions of Ghana, knowledge of their physical characteristics that are pertinent to processing and storage is crucial.

Materials and Methods

To pack the sample, the crucible was thoroughly cleaned and dried. For two hours, these samples were dried in an oven. The samples were swiftly moved using crucible tongs into a desiccator to cool after drying in an oven. As a result, measurements and records were made of the masses of three crucibles, seeds, and crucible. Every measured sample was once again oven-dried at 100°C before being weighed using an electronic weighing balance once it had cooled. Six distinct values were obtained and recorded over the six iterations of the procedure. To allow for homogeneous diffusion in the sample, a measured amount of distilled water was supplied, and the result was calculated using Equation 1 for 48 hours. In order for equilibrium to occur at room temperature, the results were removed from the refrigerator. To allow for homogeneous diffusion within the sample, the produced sample was packed in a polythene bag and refrigerated at 5°C for 48 hours. For uniformity, the outcome was removed from the refrigerator and allowed to come to room temperature.

$$Q = \frac{Wo(Mf-Mo)}{(100-Mf)} \quad (1)$$

Where Q is the quantity of water to be added (kg),
Wσ is the initial mass of the sample (kg)
Mσ is the initial moisture content of the sample(%)
Mf is the desired water content of the sample (%)

Table. 1. Moisture Contents of some Selected Samples.

Initial moisture content of the seed (Mσ)	55.870%
Desired moisture content (Mf)	60%
Mass of the seed (Wσ)	500g
Quantity of water (Q)	51.625g

Cowpea seed's average size was calculated. One hundred cowpea seeds were chosen at random. A digital vernier caliper was used to measure the randomly chosen seeds' length (L mm), width (W mm), and thickness (T mm).The following formula was used to determine the cowpea seed's arithmetic mean diameter (Da(mm)) and geometric mean diameter (Dg(mm)) from main dimension.

$$D_a = \frac{L+W+T}{3} \quad (2)$$

$$D_a = (LWT)^{1/3} \quad (3)$$

Table. 2. The average values of the physical properties of cowpea seed for wet process.

	Length(mm)	Width(mm)	Thickness(mm)
Total	695.97	558.25	400.67
Average	695.97÷100	558.25÷100	400.67÷100
	=6.9597mm	=5.5825mm	=4.0067mm

Average Diameter

Da=5.5163mm ≈ 5.52mm

Geometric Diameter
Dg= 51.8901mm

Table. 3. The average values of the physical properties of cowpea seed for drying process.

	Drying process	Drying process	Drying process
Total	752.45	611.76	464.38
Average	752.45÷100	611.76÷100	464.38÷100
	=7.5245mm	=6.1176mm	=4.6438mm

Geometric diameter
Dg=71.2543mm
Average diameters

Sphericity (ϕ)

Sphericity of cowpea seed was calculated by the following equation.

$$\Phi = \frac{(LWT)_{1/3}}{L} \quad (4)$$

$$\Phi = 7.4557$$

Ratio
The ratio aspect which is known as the function of width and length was calculated as follows.

$$R_a = \frac{W}{L} X\ 100 \quad (5)$$

$$Ra = 80.2118$$

Surface Area
Surface area of a cowpea seed was determined by,

$$S = \pi D^2_g \quad (6)$$

$$S = 95.64mm$$

Mass of 100 Seed

The mass of sample was determined by weighing 100 seed weighing balance. It was further calculated using the equation.

$$M_{100} = \left(\frac{M}{n}\right) X\ 100 \quad (7)$$

Porosity

The cowpea seed's porous space is indicated by its porosity. The following formula was used to calculate it from bulk and actual density.

$$Porosity = \frac{True\ density - Bulk\ density}{True\ density}\ X\ 100\% \quad (8)$$

Angle of Repose

A bottomless cylinder measuring 5 cm in diameter and 29 cm in height was used to measure the cowpea seeds' angle of repose. Prior to being filled with the samples, this cylinder was positioned in the middle of a square sheet and slowly raised until a cone was created on the sheet. The cone's diameter and height were measured and noted. Later, the angle of repose was computed using;

$$\theta = \tan^{-1} \quad (\frac{2H}{D}) \quad (9)$$

Where, θ is the angle of repose
H is the height of the cone (cm)
D is the diameter of the cone (cm)

Angle of Repose

Table. 4. Wet process

Diameter of cone formed by cowpea seed (cm)	Height of cone formed by cowpea seed (cm)
19.00	5.10
19.00	6.00
19.00	5.50
19.00	5.50
19.00	5.50
Average=19.00cm	**Average**=5.52cm

Table. 5. Drying process

Diameter of cone formed by cowpea of seed(cm)	Height of cone formed by cowpea
18.00	4.30
18.00	4.70
18.00	5.00
18.00	4.40
18.00	4.50
Average =18.00cm	**Average**=4.58cm

Coefficients Of Friction

Three test surfaces—glass, plastic sheet, and plywood—were used to calculate the cowpea's coefficient of friction. The cowpea seed was put into a bottomless plastic cylinder that measured 66 mm in diameter and 77 mm in height. The cylinder was then set on a frictional inclined plane. The surface and platform were gradually angled until the cylinder began to move downward; the angle at which it did so was noted. The formula was used to determine the coefficients of friction.

Where, μ_5 is the coefficient of α is the angle of inclination,

Table. 6. Wet process

Wooden	Plastic	Glass
20°	26°	22°
21°	25°	25°
22°	27°	24°
19°	26°	26°
21°	27°	23°
Average=20.6°	=26.2°	=24°
Tanμ=0.376°	0.492°	0.445°

Table. 7. Drying process

Wooden	Plastic	Glass
26°	26°	18°
23°	25°	18°
21°	26°	18°
24°	25°	17°
23°	26°	19°
Average=23.4°	=25.4°	18°
Tanμ=0.433°	0.475°	0.325°

Results

Table 8: Some measured and calculated values physical properties of cowpea.

PHYSICAL PROPERTIES (Wet basis)	VALUES (Units)	PHYSICAL PROPERTIES (Dry basis)	VALUES (Units)

Geometric properties		Geometric properties	
Length	6.9597mm	**Length**	7.5445mm
Width	5.5825mm	**Width**	6.1176mm
Thickness	4.0067mm	**Thickness**	4.6438
Geometric mean diameter	51.8901mm	**Geometric mean diameter**	71.2543mm
Arithmetic mean diameter	5.5163mm	**Arithmetic mean diameter**	6.095mm
Sphericity	7.4557mm	**Sphericity**	9.4696mm
Aspect ratio	80.2118	**Aspect ratio**	81.3024
Surface area	95.64	**Surface area**	116.77
Frictional properties		**Frictional properties**	
Co-efficient of friction		**Co-efficient of friction**	
Glass	0.445°	**Glass**	0.433°
Plastic	0.492°	**Plastic**	0.475°
Wooden	0.376°	**Wooden**	0.325°
Angle of repose	30.16°	**Angle of repose**	26.97°

Discussion

Cowpea seeds' moisture content was measured, and the results, which are displayed in table 7 above, indicate that the moisture content affects the seeds' physical characteristics on both a wet and dry basis. Wet and dry basis values for length are 6.9597 mm and 7.5445 mm, respectively, according to the table; wet and dry basis values for width are 5.5825 mm and 6.1176 mm, respectively; and wet and dry basis values for thickness are 4.0067 mm and 4.6438 mm, respectively. The values in the table were used to calculate the geometric and arithmetic mean diameters. The results for the dry and wet bases of the geometric mean diameter are 51.8901 mm and 71.2543 mm, respectively, while the results for the arithmetic mean diameter are 5.5163 mm (wet) and 6.095 mm (dry), indicating that the dry basis is greater than the wet basis. For both wet and dry bases, the resulting sphericity values are 7.4557mm and 9.4696mm, respectively. The ratio's values are 80.3024 for the wet basis and 81.3024 for the dry basis. The results obtained for surface area on both a wet and dry basis are 95.64 and 116.70, respectively. The frictional characteristics of several materials, including glass, plastic, wood, etc., were assessed in order to calculate the coefficient of friction. The wet basis is higher than the dry basis in this case, as indicated by the computed wet and dry bases of 0.445° and 0.433°, respectively, once the value of glass has been established. The wet and dry basis values for plastics are 0.492° and 0.475°, respectively. For wooden, the wet and dry base values are 0.376° and 0.325°, respectively. Finally, the cowpea seeds will completely form a mass during collecting, according to the angle of repose. Angle of repose has a crucial role in filling flat storage when seed is packed rather than gathered in a uniform bed. Both wet and dry bases yielded angle of repose values of 30.16° and 26.97°, respectively. An advantageous parameter for the maximum design of a container is the angle of repose.

Conclusion and Future Works

Certain physical characteristics of cowpeas that are grown in Nigeria may be helpful in the design of postharvest, handling, processing, and operational equipment. According to conducted experiments, the physical characteristics of cowpea seeds on a wet and dry basis change in three important ways. Physical characteristics were found to be crucial in the design of cowpea postharvest, handling, and processing equipment. The following are the findings from the investigation into the physical characteristics of cowpea seeds.

The wet cowpea's length, width, and thickness fell within the following ranges: 6.9597 mm, 5.5825 mm, and 4.0067 mm, respectively. The dry cowpea's measurements fell within the same ranges: 7.5445 mm, 6.1176 mm, and 4.6438 mm. The wet cowpea's geometric and arithmetic mean diameters were 5.5163 mm and 51.8901 mm, respectively, but the dry cowpea's were 6.095 mm and 71.2543 mm.

Additionally, the seed's surface area, sphericity, ratio, angle of repose, and coefficient of friction were measured on both a wet and dry basis.

The impact of moisture content on the physical characteristics of agricultural products, which are significant and pertinent in the processing and bulking of farm or agricultural products like fruits, vegetables, and tubers, should be further investigated.

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