

DETERMINATION OF SOME SELECTED PHYSICAL PROPERTIES OF COWPEA BORNOJI AND BANJARA GROWN IN BORNO STATE, NIGERIA

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ABSTRACT

A study was undertaken to determination of selected physical properties of cowpea related to design of processing machine. Two varieties of cowpea (Banjara and Bornoji) grown in Maiduguri, Borno State, Nigeria were selected for the study. The selected properties are: the mean weight of 1000 seeds of cowpea found to be 216g for Bornoji and 184.5g for Banjara. The longest seed length 5.89mm for Bornoji and the least 4.09mm for Banjara., the seed thickness 2.97mm for Bornoji and 1.89mm for Banjara. The mean angle of repose for Bornoji was 26.29° and for Banjara was 25.75°, respectively. The geometric mean diameter was highest for Bornoji 3.75mm³ and least for Banjara 3.36mm³. The mean surface area for Bornoji was 44.18mm² and for Banjara was 35.47mm². Mean bulk density values obtained showed that Banjara was 0.43kg/m³ and Bornoji 0.37kg/m³. The mean seed volume for Bornoji was 11.78mm³ and for Banjara was 10.5mm³.

Keywords: cowpea, Banjara, Bornoji, Bulk density

1 INTRODUCTION

Nigeria is the largest producer and consumer of cowpea in all West Africa [1]. More than 8 million hectares of cowpea are grown in the West and Central Africa and they serve as a good source of protein, energy and other nutrients. Nigeria is the largest producer with 4 million hectares, followed by Niger with 3 million hectares. Other producers include: Mali, Senegal, Burkina Faso, etc., [1]. Cowpea can be processed into various finished and semi-finished products. The advantages of cowpea processing include improving digestibility, reducing or eliminating anti-nutritional factors, improving consumer appeal and acceptability, extending shelf-life, income generation, etc. The flour is less prone to insect pest attack and can be stored for relatively longer period of time. Cowpea flour is usually rehydrated and utilized in formulations as desired. Cooked cowpea seeds can be consumed in form of cooked whole cowpea or cooked de-hulled cowpea. Whole cowpea (with intact testa) takes longer period of time to cook than de-hulled cowpea. Cooked whole cowpea is eaten whole or de-hulled, either alone or in combination with other food products like bread, *garri*, boiled yam with vegetable soup. Cowpea flour is used to prepare *akara* (bean cake), *danwake* (cowpea dumplings), and *moi-moi* (steamed cowpea paste). Cowpea seeds are utilized whole or processed into flour and further into paste. Cowpea seed is a nutritious component in the human diet as well as a nutritious livestock feed. Cowpea is used at all stages of growth as a vegetable crop. It is cultivated mainly for its seeds which can be processed into flour which is used to make cake, *akara* balls, etc., into paste to make *moi-moi* (pudding), or even cooked and eaten alone. It gives the working mothers the opportunity to prepare this favorite meal with the comfort it provides. The high protein content of cowpea makes it an excellent fodder crop. Various parts of cowpea are used medically. Cowpea is a good fertilizer because of its ability to fix nitrogen from the air. Cowpea grain contains about 25% protein and 64% carbohydrate and the product can be marketed through market women, food canteens, hotels and super markets. Both physical and mechanical properties are important factors in solving problems associated with the design of specific machines or analysis of the behavior of the product

during agricultural processes such as planting, harvesting, and handling, threshing, sorting, and drying. Solution to these problems involves having the knowledge of the physical and the mechanical properties of products [2]. Mechanical damage to cowpea during postharvest handling, processing, and storage remains a major problem to cowpea farmers. Therefore, a rational approach to the design of agricultural machinery, equipment and facilities will involve the knowledge of the physical properties of the cowpea. Hence the need for this study “Determination of some selected physical properties of cowpea grown in Borno State, Nigeria”. It is important to have an accurate estimate of shape, size, volume, density, surface area and other physical properties that may be considered as engineering parameters for the product. Also, mechanical damages to seeds which occur during harvesting, threshing, and handling can seriously affect viability and germination, growth vigour, insect and fungi attack and also the quality of final products.

2 METHODOLOGY

The study was conducted in the Agricultural and bio environmental Engineering Laboratory of the Ramat Polytechnic Maiduguri. The study area is in Maiduguri the capital of Borno State in Northeastern Nigeria. The study area is located between latitude 11.802273° N and 11.805671°N and longitude 13.177060°E and 13.224816°E, in a semi-arid region. Rainfall in the area is estimated at 600mm per annum while evapotranspiration is over 2000mm per annum. Climatically, the study area is hot and dry for the greater part of the year. The rainy season is normally from June to September, with relative humidity of about 49%. The temperature ranges from 13°C to 25°C in October through February, while in March - May it is between 35°C and 39°C.

2.1 Materials

The materials that were used in the course of this study include: Cowpea seeds, an oven, a Vernier caliper, a stop clock, a weighing balance, measuring ruler, a conical flask, constructed box measuring 200×200×200mm for measuring angle of repose.

2.2 Method of Sample preparation

The two varieties of cowpea were bought from Maiduguri market in Borno State, N Northeastern Nigeria on 27th September, 2021. The sample were selected and cleaned manually. It was ensured that the seeds were free of dirt, broken and immature ones and other foreign materials. The experiments were conducted for the two varieties of cowpea: Bornoji beans, and Banjara beans at the moisture content levels of 15% an 30% dry basis respectively.

2.3 Determination of cowpea physical properties relevant to the design of a processing machine

Physical properties of cowpea are necessary for the design of equipment to handle, transport, process and store the crop.

2.3.1 Determination of Size

A venire calliper was used to measure the axial dimensions of randomly selected 100 seeds; length, width, and thickness were measured in three mutually perpendicular directions. After the determination of the dimensions, the averages were calculated. From the average of axial dimensions, the geometric mean diameter D_g in (mm) was determined using the equation below [4].

$$D_p = (abc)^{1/3} \quad (1)$$

Where, a= Length (mm), b= Width (mm), c= Thickness (mm).

2.3.2 Determination of Volume

The volume of the cowpea was determined by taking the dimensions of the cowpea in three axes of length, width, and thickness. Then the volume was estimated using the following relationship as described by [4].

$$V = \left\{ \frac{\pi lwh}{6} \right\} \quad (2)$$

Where V = Volume of cowpea (m^3), l = Length of cowpea (mm), w = Width of cowpea (mm), h = Thickness of cowpea (mm), π = Constant.

2.3.3 Determination of Bulk density

Bulk density of the cowpea was determined by weighing the cowpea pack in a container of known volume. The cowpeas are densely packed by gently tapping the container to allow the settling of cowpea in the container [5].

$$\rho_b = \frac{M}{V} \quad (3)$$

Where ρ_b = Bulk density (kg/m^3), M = Mass (kg), V = Volume (m^3).

2.3.4 Determination of Angle of repose

The angle of repose was measured using a specially constructed box measuring $200 \times 200 \times 200$ mm with a detachable front panel [6]. The box was filled with the cowpea at different initial moisture contents and the front panel was removed quickly. The cowpea was allowed to flow according to their natural flow pattern. The angle of repose was calculated by measuring the distance between the end of the flow and the box.

$$\theta = \tan^{-1} \left(\frac{2H}{D} \right) \quad (4)$$

Where, θ = Angle of repose, H = height of the free surface of the cowpea (mm), D = Length of the heap formed outside the box (mm).

2.3.5 Determination of thousand cowpea seed weight

In determining the weight of the cowpea, one thousand (1000) whole seed of cowpea was weighed using the electronic weighing balance of 0.01g sensitivity.

2.3.6 Determination of Porosity

Porosity or bulk porosity was determined using the bulk and solid densities parameters as described by [4].

$$\varepsilon = \left(\frac{\rho_t - \rho_b}{\rho_t} \right) \times 100 \quad (5)$$

Where, ρ_t = True density (kg/m^3), ρ_b = Bulk density (kg/m^3), ε = Porosity.

2.3.7 Determination of Static coefficient of friction

The static coefficient of friction for the cowpea at different moisture contents was obtained by applying the inclined plane method which involved using a hollow metal cylinder open at both ends and filled with cowpea. The cylinder was then placed vertically on an adjustable tilting plate without allowing the metal cylinder to touch the inclined surface. The tilting was raised slowly and gradually until the cylinder just started to slide down and the angle of inclination was read from a graduated scale.

$$\alpha = \tan^{-1}(\mu) \quad (6)$$

Where, μ = Static coefficient of friction, α = angle of inclination (degrees).

2.3.8 Determination of Surface area (S)

The surface area of the cowpea was assessed by analogy with a sphere of same D_g , using equation 7 by [7].

$$S = \pi D_g^2 \quad (7)$$

Where S = Surface area mm^2 , D_g = geometric mean diameter (mm).

3 RESULTS AND DISCUSSION

Table 1 shows the results that there were significant differences in all the properties tested. The mean weight of 1000 seeds of cowpea were (216g) for Bornoji and (184.5g) for Banjara. The variation in weight can be attributed to their difference in moisture content and size of the varieties considered

[8]. The greatest seed length (5.89mm) was for Bornoji and the least (4.09 mm) was for Banjara (Table 1). Also, the greatest seed thickness (2.97mm) was found in Borboji and least (1.89mm) in Banjara. These results were a bit closer to that of the African breadfruit (*Genus species*) seed and gram (*Genus species*) with reported average principal dimensions of 11.91, 5.69, 4.64mm, and 7.98, 5.95, 5.82mm respectively [8] and smaller than the oil bean (*Genus species*) seed with corresponding dimensions of 65.4, 41.3, and 13.7mm [8]. Tri-axial dimensions knowledge of the seeds is important in determining aperture sizes in the design of grain handling machinery [8]. The above results show that, a single multivariate machine could be used for gravity and hydro separation of foreign materials from the five varieties. However, a single machine could be used in handling, cleaning and grading of these varieties. The mean angle of repose of Bornoji was 26.29° and for Banjara was 25.75°, respectively. The angle of repose determines the maximum angle of a pile of grain in the horizontal plane, and is important in the filling of a flat storage facility when grain is not piled at a uniform bed depth but is peaked [9]. The geometric mean diameter was highest for Bornoji 3.75 mm³ and least for Banjara 3.36 mm³. The mean surface area for Bornoji was 44.18 mm² and for Banjara was 35.47 mm². Mean Bulk densities values obtained showed that Banjara was 0.43kg/m³ and for Bornoji 0.37kg/m³. It was observed that Banjara with smallest linear dimensions had the greatest bulk density. This could be adduced to the fact that small seeds are likely to be well compacted than the larger ones. The mean seed volume was highest for Bornoji 11.78 mm³ and least for Banjara 10.54 mm³.

Table 1. Physical Properties of two cowpea varieties

Parameters	Bornoji Mean	Banjara Mean
Length, L (mm)	5.32	4.63
Width, W (mm)	3.71	3.42
Thickness, h (mm)	2.64	2.39
G M D Dg (mm)	3.75	3.36
Volume, v (mm ³)	11.78	10.54
Sphericity (%)	70.45	72.57
Surface area (mm ²)	44.18	35.47
TKW (g)	216	184.5
Bulk density (kg/m ³)	0.37	0.43
Angle of repose	26.29	25.75

4 CONCLUSIONS

Some physical properties of two varieties of cowpea grown in Nigeria which may be useful in designing equipment for postharvest handling and processing operations were determined. Statistical test showed that there are significant differences between the physical properties of the two crops studied. It was established that the determined physical properties are vital for the design of postharvest handling and processing equipment for cowpea.

REFERENCES

1. Ezeoha, S.L., N.N., Aneke, A.C. and Ezeagba, U.F.N. (2019). Effect of Soaking Time and Temperature on Some Physical and Mechanical Properties of Cowpea. *Journal of Scientific and Engineering Research*, vol. 6, no. 3, pp. 41-58.
2. Irtwange, S.V. and Igbeka, J.C. (2002). Some physical properties of two African yam beans accessions and their interrelationship with some moisture content. *Applied Engineering Agriculture*, vol. 18, pp. 67-576.
3. Joshi, D.C., Das, S.K. and Mukherji, R.K. (1993). Physical properties of pumpkin seeds. *Journal of Agricultural Engineering Research*, vol. 54, pp. 219-229.
4. Mohsenin, N.N. (1986). *Physical Properties of Plant and Animal Materials*, 2nd Ed. Gordon and Breach Science Publishers, New York.
5. Ndirika, V.I.O. and Oyeleke, O.O. (2006). Determination of selected physical properties and their relationships with moisture content for millet (*pennisetum glaucuml.*). *Net Journal of Agricultural Science*, vol. 1, no. 4, pp. 100-106.

6. Aviara, N.A., Oluwole, F.A. and Haque, M.A. (2005). Effect of moisture content on some physical properties of sheanut (*Butyrospermum paradoxum*). *International Agrophysics*, pp. 193-198.
7. Singh, K., Pardeshi, I., Kumar, M., Srinvas, K. and Srivasva, A. (2010). Optimization of machine parameters of a pedal-operated paddy thresher using RSM, Threshing machine suits for threshing black seeds (*nigella sativa*). *Misr Journal of Agricultural Engineering*, vol. 24, no. 4, pp. 699-724.
8. Omobuwajo, O.T., Akande, A.E. and Sann, A.L. (1999). Selected Physical, Mechanical and Aerodynamic Properties of African Breadfruit (*Treculia Africana*) Seeds. *Journal of Food Engineering*, vol. 40, pp. 241-244.
9. Olajide, J.O. and Igbeka, J.C. (2003). Some Physical Properties of Groundnut Kernels. *Journal of Food Engineering*, vol. 58, pp. 201-204.