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Some Physical Properties of Negro Pepper Seed (*Xylopia Aethiopica*) Necessary for Post- Harvest Handling

Elijah G. Ikrang; Anyanwu, C. Solomon

Department of Agricultural and Food Engineering, University of Uyo PMB, Uyo, Nigeria

ABSTRACT
Negro pepper is a spice with high nutritional value and several beneficial phytochemical compounds. Physical attributes of biomaterial are important in many problems associated with the design of machines and the analysis of the behavior of the product during agricultural processing operations such as handling, planting, harvesting, milling, threshing, cleaning, grading, sorting and drying. This study was aimed at determining some physical properties of Negro pepper seed (xylopia aethiopica) including axial dimensions, grain mass, bulk and true densities and porosity. Manual methods of measurements were employed in which the seeds were either measured directly or in bulk. Other parameters were calculated such as arithmetic, geometric mean diameter and sphericity. Seed weight and volumes were measured by using standard measuring equipment. All properties were determined at a fixed moisture content. The result of the study showed that the average length, width and thickness of the negro pepper seed were 5.99 $\pm$0.42, 3.51 $\pm$ 0.25 and 3.05$\pm$0.14mm respectively. Geometric mean diameter and sphericity of the Negro Pepper Seed were obtained as 3.80 $\pm$0.13mm and 65.53.$\pm$0.11% respectively. The Solid density, Porosity and bulk density for negro pepper seeds were 0.56 $\pm$0.25 g/m^3 49.50 $\pm$0.22 % and 1.125 $\pm$0.31 g/m^3 respectively all measurement were obtained at a seed moisture content of 37.5% wet basis.

KEYWORDS: *Negro pepper seed, physical properties, sphericity, true density, bulk density*

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INTRODUCTION

The size and shape of an agricultural commodity, or of a processed product, not only affect the degree of consumer acceptance but in many cases influence packaging, distribution of stresses when forces are applied, and processing ability. As pointed out by Medalia (1980) "to define the shape of a body fully, one must specify the location of all points on the external surface." This is not only a time-consuming process but also has mathematical difficulties for more irregular shaped commodities. Therefore, qualitative shape description is the most popular with food graders. The shapes of fruits and vegetables have been classified into 13 categories such as round, oblate, oblong, conic, elliptical, truncated, ribbed, etc. (Mohsenin, 1980).

Benefits of the Negro Pepper

Every parts of the Negro pepper plant such as the bark, seeds, stem, fruit and leaves are of great importance in medicine for therapeutic purposes. Furthermore, some parts of crop can be combined with other plants parts for tackling many ailments and diseases. Researchers revealed that Negro pepper contains anti-oxidizing, calmative, laxative and antimicrobial properties .The seeds can be added whole or crushed before being used to prepare assorted food dishes such as soups, yam porridge, pepper soup, stews, sauce, meat and fish etc. It can also be used alone or mixed with garlic or ginger for making herbal tea. Negro pepper can also be used as a preservative Abolaji *et.al.*, (2007). Negro pepper seeds can be crushed and mixed with the roots of Gardenia tennifolia for preparing herbal tonic for treating coughs, fever, flu and cold. The crushed Negro pepper seeds can also be mixed with other ingredients for the treatments of other ailments such as rheumatism, gastrointestinal problems, respiratory system disease, menstrual problems Abolaji *et al.,* (2007).

The nutritional and health benefits of spices are gaining wide acceptance as they are being sold in various forms in many marketing outlets in Nigeria. Tairu (1999) Negro pepper can be used medicinally as a cough remedy, a post-partum tonic and a lactation aid others are for treatment of stomachache, bronchitis and dysentery. The dried fruits are also used as spices in the preparation of two special local soups named “obeata” and “isi-ewu” taken widely in the Southwest and Southeastern parts of Nigeria respectively *(*Abolaji *et al., 2007*). In the course of exploiting the usefulness of this seed, they are usually subjected to various processing and unit operations which do affect these qualities. Cooking or roasting alters the nature of many spice constituents like starches, proteins and volatiles by changing their physical, chemical and nutritional characteristics.

Fig 1 (a) Dried Negro pepper fruit pods in clusters (b) Negro Pepper Seeds

Many spices including negro pepper are ground to coarse or fine particles to provide convenience for human consumption. Further, the unit processing from harvesting to milling adds to the cost and hence becomes a process of value addition. The immediate question that arises is the quality of the ground material; a processor always tries to maintain the same quality in the finished product compared to the original sample (whole seed). It is obvious that some portion of input mechanical energy is transformed into thermal energy during grinding (milling). The extent of transformation of mechanical energy depends on several factors including raw material attributes, type and design of the material handling system, and engineering properties of the material and the processing machine. Thus, there is a need to know how these factors affect the quality and characteristics of the finished product. Other issues that may come up is the extent of deterioration of quality which may directly or indirectly affect market value. In the present era of competitive world trade, it is very important that the quality of the product should be of international standards. The last question that arises here is how to maintain or improve the quality of the product. Not much work has been carried out to find the answers to these questions.. But detailed scientific data are still lacking to solve these problems.

Negro Pepper seed play a vital role in the socio-economic and health wellbeing of the people, at every stage of harvest, handling and packaging operation care must be taken to avoid injuries thereby reducing quality. Having found that not much work has been done on the physical properties of negro pepper seed to enhance its processing with the attendant benefit to humans, this work was then carried out with the following objectives .To determine some physical properties of negro pepper seeds such as axial dimensions ,mass, bulk and true density and some parameters calculated were sphericity, surface area, geometric mean diameter amongst others. These properties help to enhance handling (harvesting, cleaning, drying, milling and storing)

Materials and Method

Sample procurement and preparation

Negro pepper dried fruits were bought from a local market (*Urua Akpan Andem*) in Uyo, the viable seeds were manually extracted, sorted after removing the seed from the pods. The seeds were then wrapped in a polyethene bag and kept in a refrigerator

Size and Shape

From the selected samples,100 seeds were picked at random ,measurements of dimensions on three naturally perpendicular axes were made namely major, intermediate and minor diameters. The measurements were made with a digital micrometer screw gauge with a resolution reliability error of 0.01mm respectively. The most prevailing method for quantitative shape description involves calculations of similarity to a sphere:

$$Spherecity(S) = \left({(abc)}/{a} \right)^{1/3} \qquad (1)$$

where:
a is the major axis of the product.(mm)
b is the intermediate (medium) axis of the product and(mm)
c is the minor axis of the product.(mm)

$$Roundness R_d = {A_p}/{A_c} \qquad (2)$$

where A_p is the largest projected area of the object in natural rest position and Ac is the smallest circumscribing circle. A value of roundness (R_d) equal to unity is a perfect sphere, and increase in the value indicates more sharpness in the product. .

Other practical methods of determining the, sizes of fruits and vegetables are diameter or length measurements, and counts per weight or volume. With fruits, the larger size is most desirable for the trade market. The other way of expression is weight per 100 or 1000 seed.

Geometric Mean Diameter (D_G)

The geometric mean diameter was determined from the Length (L), Width (W) (intermediate axis)and Thickness (T) using Equation 3

$$D_G = [LWT]^{1/3} \qquad (3)$$

Where: geometric mean diameter (D_G)

Equivalent mean diameter (D_E)

The equivalent mean diameter was determined from the relationship:

$$D_E = L\left[{(L+T)^2}/{4} \right]^{1/3} \qquad (3a)$$

Arithmetic Mean Diameter (D_A)

The arithmetic mean diameter was determined from the three principle diameter using the relationship by Mohsenin (1970):

$$D_A = (L + W + T)/3 \quad (4)$$

where:
L is the length, (dimension along the longest axis in mm;
W, is the width, (dimension along the longest axis perpendicular to (L) in mm) and
T, is the thickness, (dimension along the longest axis perpendicular to both (L) and (W) in mm).

Volume and Density

The product is weighed in air and in water (using analytical balance, or a special gravity balance) and the volume is calculated:

$$Volume = (Weight \quad in \quad air - Weight \quad in\ water)/ Weight\ density\ of \quad water \quad (5)$$

Density of solids was calculated as the ratio of weight and volume. Separation by density in floatation is also used with many agricultural commodities to remove defective materials and extraneous matter.

The volume of the seed was determined by using the following formula

$$Volume = \pi BL^2 / 6(2L - B) \quad (6)$$

where;
B = $(WT)^{1//2}$
L = Major diameter, mm
W = Intermediate diameter, mm
T = Minor diameter, mm
$\pi =$ a constant

Bulk and True densities

The bulk density was determined by filling an empty 1000ml graduated cylinder with the seed and weighed (Mohsenin, 1986). The weight of the seeds was obtained by subtracting the weight of the cylinder from the weight of the cylinder and seed. To achieve uniformity in bulk density the graduated cylinder was tapped 10 times for the seeds to consolidate as reported by Irtwange (2000).

The volume occupied was then noted. The process was replicated 24 times and the bulk density for each replication was calculated from the following relation:

$$\rho b = Ws/Vs \quad (7)$$

where: the p_b is the bulk density in kg m^3;
W_s is the weight of the sample in kg;
V_s is the volume occupied by the sample in m^3.

The mean value, variance, SD and CV for the 24 replications was determined to obtain the bulk density.

The true density was determined using the water displacement method. This method was used having certified that the seed coat is very hard and does not absorb water. Prior to the experiment, some seeds were weighed and soaked in water for 60 min and thereafter weighed to ascertain increase in weight due to absorption.

A known weight of the seeds (34.3 g) was measured and the number of seeds (N) in the sample was carefully counted. Water was poured into a Eureka can and allowed to level up with the fraction. The seeds were then poured into the can and the volume of water displaced was measured using a 50ml measuring cylinder. The process was replicated 24 times and the true density taken as the average of the 24 replications was calculated for each reading as:

$$\rho_t = W_s / V_w \quad (8)$$

where: p_t is the true density in kgm^{-3};

The surface area was determined by using the following equation as cited by Sacilik *et al.*, (2003), Tunde-Akintunde and Akintunde (2004) and Altuntas *et al.*, (2005):

$$Sa = \pi GMD^2 \quad (9)$$

Where;
Sa = surface area (mm^2)
GMD = geometric mean diameter (mm)

Determination of Moisture Content

The moisture content of the samples was determined by oven drying method at 130°C for 19hours, and all weight loss was considered to be moisture, according to the standardized procedure for moisture content determination by ASABE standard S352.2 (2007). The moisture of the seed in % (wet and dry basis) was calculated using the following formula (Mohsenin, 1970).

$$Mc_{wb} = (W_2 - W_3)/(W_2 - W_1) \quad (10)$$

where Mc_{wb} = moisture content wet basis of seed (%) respectively, W_1 is the weight of the can, W_2 is weight of the can + moist sample and W_3 is the weight of the can + dry sample (g) respectively.

Angle of repose

A vertical cylinder container was placed open at both ends on a flat surface. The empty cylindrical container was filled with clean negro pepper seeds and cylindrical container was carefully lifted gradually and form a pile (Irtwange, 2000). The radius of spread and the height of the cone formed by the heap of seed were measured. This procedure was repeated in five (5) replicates and their average was used to calculate the angle of repose from:

$$\phi_r = \tan^{-1}[2h/r] \quad (11)$$

Where: ϕ_r is the angle of repose;
h is the height of the cone in mm,
r is the radius of spread in mm.

Coefficient of friction on some material surfaces

The coefficient of friction on some material surfaces was determined using the set up similar to the one used for determination of coefficient of internal friction except that instead of the guide frame, the seeds were placed on a table with changeable surface. The experiment was conducted on three material surfaces; (wood, glass and metal surface) by a method described by Dutta *et al*.,(1998). The experiments were replicated ten (10) times for each surface The seeds were placed inside a cylindrical container on plane of a named material slightly raised to avoid direct contact between the surface and the cylinder. The plane was gently tilted and the angle of inclination at which the sample start sliding was read off the protractor attached to the apparatus. The tangent of this angle is reported as the coefficient of static friction

$$\phi s = \tan\phi \qquad (14)$$

ϕ_s = coefficient of friction

ϕ = angle of inclination

Results and Discussion

Size

The results obtained shows that the mean length, width , thickness and standard deviation of Negro pepper seeds were found to be 5.99mm ± 0.42 , 3.51mm $\pm 0.0,25$ and 3.05mm ± 0.14 respectively, as compared to that obtained by Fashina (1996) which was 5.87mm, 3.51mm and 3.10mm respectively. The geometric mean diameter, Equivalent mean diameter and arithmetic mean diameter were found to be 3.8mm ± 0.13, 15.29mm ± 0.21, 3.99mm ± 0.15

Table1. Summary of results for Some Physical Properties of Negro Pepper Seeds analyzed

Physical Property	Mean	SD
Length (mm)	5.99	0.421
Width (mm)	3.51	0.250
Thickness (mm)	3.05	0.146
Geometric Mean Dia, Dg (mm)	3.8	0.13
Equivalent Mean Diameter, D_p	15.29	0.21
Arithmetic Mean Diameter, D_a	3.99	0.15
Bulk Density	0.56	0.25
Solid Density	1.12	0.31
Porosity	49.5	0.22
Sphericity Determination	65.53	0.11
Estimated Surface Area	45.37	0.18
One Thousand Seed Mass	34.3	-
Moisture Content on Wet Basis	3.75	0.12
Angle of Repose	35^0	
Coefficient of friction (glass)	30.99^0	
Coefficient of friction (wood)	29.34^0	
Coefficient of friction (steel)	30.64^0	

Angle of Repose

From the results on Table 1, after five replicates of the angle of repose of the negro pepper seeds, the mean height and radius of spread were 1.74cm and 5.03cm respectively as compared to that obtained by Fashina (1996) which was 1.70cm and 5cm respectively. And applying the result obtained into the angle of repose formula, gave the angle of repose as $\phi = 35^o$.

Coefficient of friction on Some Materials

The results of the coefficient of friction on four surfaces are as presented on Table 1 . Since the coefficient of friction is a function of the angle of internal friction, it is inevitable that changes that affect the internal friction of the material affect the coefficient of friction of the material.

From the table, the coefficient of friction increased in all the four surfaces used as the height of inclination increased.

The fact that the densities of the seeds are less that the density of water can be used to design separation or cleaning processes for the grains since lighter fractions will float. The values recorded for the Bulk and True densities of negro pepper seeds is as presented Table 1 From the experiment, the values of the bulk density and true density of the negro pepper seeds were revealed as 0.568g/ml^3 and 1.125g/ml^3 respectively. This shows that the bulk weight of the seeds per volume is less than the mass per volume of the seeds. The result obtained were in cognizance of that obtained by Showalter (1973) which was 0.567g/ml^2 and 1.126g/ml^2.

Bulk and True Densities:

No increase in weight was noted. This is why the seeds are usually heat treated to soften the seed coat and allow for easy water absorption, baked overnight before they are planted

Food powders pose problems in volume and density measurements because of their packing characteristics. Generally, two types measurements are useful: free flow density and tapped density, the difference being in the manner of filling the volumetric container. Tapped density gives a higher number than free flow density because of partial displacement of air from between the particles. Free flow and tapped density relate to the container fill and settling during shipment and handling.From the experiment, the mean values of the bulk density and true density of the negro pepper seeds were found to be 0.568g/ml^3 and 1.125g/ml^3 with a standard deviation of 0.25 and 0.31 respectively. These shows that the bulk weight of the seeds per volume is less than the mass per volume of the seeds. The results obtained were in line with the work carried out by Showalter (1973) which was 0.567g/ml^2 and 1.126g/ml^2 respectively.

Surface Area

The value of the estimated mean surface area was 45.37mm^2.± 0.18 The surface area of an agricultural product is generally indicative of its pattern of behavior in a flowing fluid such as air, as well as the ease of separating extraneous materials from the product during pneumatic transport It is also important in heat and mass transfer processes such as drying and other thermal applications.

Sphericity

Published values for the sphericity of fruits are of the order 89-97. These values are expressed as the percentage; the higher the number, the greater the similarity to a sphere. Oblong-shaped products, such as rice, would exhibit a low value of sphericity (Mohsenin, 1986). The value of the sphericity had a mean of 65.53% ± 0.11 This shows that the seeds are entirely curved without sharp edges and that it is 65.53% compared to a sphere of 100%.

One thousand Seed Weight

From the experiment, values recorded for a thousand-seed weight was found to be 34.3g on the average and this agrees with the work done by Waziri and Mittai, 1997); and Jaeger, 1997.

Moisture Content

The moisture contents (wet basis) of Negro Pepper Seeds was found to be 3.75% ± 0.12 . The moisture content of negro pepper simply indicates the amount of water present in that agricultural produce and this is of great importance to food scientists and processing engineers as it assists them to determine certain adaptation and resistance to processing stages such as drying, bagging, storage, cooking and even consumption.

Conclusion

The results of the research were found to be useful as summarized in Table 1. The parameters investigated include length, width and thickness of the negro pepper. Others are Geometric, equivalent and arithmetic mean diameters, bulk and solid density, porosity, roundness, sphericity and moisture content. The values were in compliance with the work earlier carried out in this area.

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