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Determination of Some Selected Physical Properties of Different Maize Varieties (Zea Mays) Related to Design of Processing Machines of Nigeria

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Abstract: *The design related physical properties of six-selected Improved Institute for Agricultural Research Maize varieties were investigated. The properties will enhance design and development of production, processing and storage equipment for the crop. The mean results obtained for the different collections ranged from 7.42 to 15.63%, 8.2mm to 10.4mm, 7.1 to 9.1mm, 4.0mm to 5.0mm, 6.6mm to 7.2mm, 133mm2to 161mm2, 0.62% to 0.81%, 0.46% to0.82%, 692.42kg/m3to 747.86kg/m3, 1162.54kg/m3 to1447.7kg/m3,37.79%to 46.69%, 203.62g to 306.86g, 170.09mm3to 234.59mm3, 35.8o to 46.6ofor moisture contents, length, width, thickness, equivalent diameter, surface area, sphericity, roundness, bulk density, solid density, porosity, one thousand seed weight, volume and angle of repose respectively. The result revealed minor variations in some of the physical parameters determined indicating that differences in varieties are not very important in equipment design and development.*

Keywords: *Angle of repose, sphericity, porosity, roundness, bulk density, solid density*

I. Introduction

Maize or corn is the most important cereal crop in sub-Saharan Africa and with rice and wheat, one of the three most important cereal crops in the world. Maize is high yielding, easy to process, readily digested, and cheaper than other cereals. It is also a versatile crop, growing across a range of ecological zones. Every part of the maize plant has economic value, the grain , the leaves, stalk, tassel and cob can all be used to produce a large variety of food and Non-food products. In industrialized countries, maize is largely used as a livestock feed and as a raw material for industrial products, while in developing countries ,it is mainly used for human consumption. Maize has been in diet of Nigerians for centuries, despite that the production systems in sub-Saharan Africa (to which Nigeria belongs) often lack use of mechanized operations.(Wikipedia.,011).

In many parts of Northern Nigeria De-husking is still done by hand and threshing is either done by the use of hands, stick or mortar and pestle. There are small to medium scale processing equipment but their usage are still limited to few locations. With new varieties of seed some of these equipment will definitely need upgrading. Looking at the traditional production system, a lot of energy and time would be wasted if large scale production is to be done. Hence an improved process of utilizing the limited time available and equally reducing the energy demand is essential. To achieve this, determination of physical properties will help in the design and development of large scale processing equipment that would reduce the processing time,labor, as well as production losses. This would improve the process, add value and quality to the seeds.The main objective of this study was to determine some selected design related physical properties of Improved Maize seed varieties released by Institute for Agricultural Research, IAR, Samaru, Zaria.

II. Materials And Methods

2.1: Samples Selection and Preparation

The samples used in this study were provided by Institute for Agricultural Research, Ahmadu Bello University, Zaria, and Kaduna-state, Nigeria. Six collections of maize seeds, namely:(Sammaz 17,Sammaz 28, Sammaz 29,Sammaz 32,Sammaz 33 and Sammaz 36) were used for the study. All the collections were manually cleaned to free the seeds from dirt, dust, stones, damaged/immature seeds and other foreign materials.

2.2: Experimental Procedure

Thirty seeds were randomly selected from each variety for determining three major dimensions (length, width, thickness). A micrometer screw gauge having a sensitivity of 0.01mm was used to obtain the dimension of the sizes.

2.3: Equivalent diameter and Sphericity

This was determined using the equation given by (mohsenin, 1986) as:

$D_e = (LWT)^{1/3}$, O= $D_e/L = (LWT)/L$

Where: D_e= Equivalent Diameter(mm) and O = Sphericity, L = Length,(mm), W=width,(mm), T= Thickness,(mm). Equivalent diameter was computed thirty times.

2.4: Roundness and Surface Area

Roundness was determined using an overhead projector, five replications were done. The seed was projected on a graph paper such that the largest projected area of the seed material in natural rest position(AP) was obtained and the area of smallest circumscribing circle (AC) was also obtained. Surface area was also determined using an overhead projector, Sample of seeds was projected on a graph paper, the surface area was calculated by counting the number of boxes .(Mohsenin,1986).

Roundness = (AP/AC), The measurement was replicated five times.

2.5: Solid density, Bulk density and Porosity

In case of solid density the following relationship given by Mohsenin (1986) was used. The seed volume was determined using a measuring cylinder. A known weight of the seed was dropped into the measuring cylinder containing water. The volume of the seed was determined from the displaced volume, where as the bulk density was determined from the following relationship given by (waziri and mittal.,1986):

$P_b = M/V_b$, $P_s = M/V_u$

Where; P_S = Solid density (kg/m^3) , P_b = Bulk density (kg/m^3)

m= mass of material (kg) , V_u = Unit volume(m^3),V_b= Bulk volume(m^3)

Porosity of the seed was computed from the values of solid and bulk density of the seeds by using the relationship given by (Mohsenin,1986):

$P = \{(1-(P_b/P_s) X100\}$,

Where; P = Porosity (%), P_b= Bulk density (kg/m^3), P_s = Solid density (kg/m^3).

2.6: Seed volume and Moisture Content

The Samples volume were calculated from the following relationship:

Volume ={ (weight of displaced kerosene (kg))/Weight density of kerosene (kg/m^3)}

The Moisture contents was determined by oven drying method, samples of known weight was stored in an oven at a temperature of 105o for about 15 hours. Moisture Contents was computed by the following equation.

$M = \{W_m/ (W_m+ W_d)\}X100$

Where : M = Wet basis moisture contents expressed in (%)

Wd = Mass of dry matter (kg)

Wm = Mass of moisture (kg)

Five replications were made for each variety.

2.7: Angle of Repose

In this method, a frame box was mounted on a flat wooden surface. The box was filled to two third capacity, placed on the flat surface and then gently lifted until the seeds began to slide. The angle the surface made with the horizontal just before the seedsbegan to slide was measured as the angle of repose for the material. This was replicated five times for each variety.

III. Statistical Analysis

The measured data were subjected to descriptive statistics such as mean, standard deviation and coefficient of variation.

3.1: Results and Discussion

Table 3.2: The summary of the results for the measured design related physical properties.

Parameter	Sammaz 17	Sammaz 28	Sammaz 29	Sammaz 32	Sammaz 33	Sammaz 36
Length(cm)	0.97	0.82	1.04	0.87	1.04	1.03
Width(cm)	0.82	0.71	0.91	0.81	0.85	0.84
Thickness(cm)	0.41	0.50	0.40	0.46	0.43	0.42
Equivalent diameter(cm)	0.69	0.66	0.72	0.68	0.72	0.71
Surface Area(cm2)	1.61	1.33	1.54	1.35	1.48	1.58
Bulk density(kg/m3)	747.86	725.72	737.18	720.78	692.42	719.66
Solid density(kg/m3)	1447.7	1172.27	1265.7	1248.76	1287.16	1162.54
One thousand Seed Weight (g)	241.35	230.62	244.35	203.62	265.82	306.86
Volume(mm3)	204.85	197.48	207.78	170.09	225.19	234.59
Angle of Repose(degrees)	43.6	37.6	44.4	35.8	44.8	46.6
Moisture Contents (%)	9.73	8.18	13.89	7.42	14.15	15.63
Sphericity (%)	71	81	70	76	62	72
Roundness (%)	69.50	82.32	46.07	75.88	55.66	57.12
Porosity (%)	46.69	38.08	41.58	41.64	44.91	37.79

Table 3.3: Summary of Means, Standard deviations and Coefficient of Variations

Parameter	Mean	Standard Deviation (S.D)	Coefficient of Variation (C.V)
Moisture Contents(%)	11.5	3.18	27.65
Length(cm)	0.96	0.09	9.4
Width(cm)	0.82	0.06	7.32
Thickness(cm)	0.44	0.03	6.82
Equivalent Diameter(cm)	0.69	0.02	2.89
Surface Area(cm2)	1.48	0.11	7.43
Sphericity(%)	72	5.80	8.06
Roundness(%)	64.43	12.6	19.55
Bulk Density(kg/m3)	723.9	17.2	2.38
Solid Density(kg/m3)	1264	94.2	7.45
Porosity(%)	41.78	3.26	7.80
One thousand(g)	241.9	45.7	18.89
Angle of repose (degree)	42.13	3.98	9.45
Volume(mm3)	206.7	20.6	9.97

3.4: Comparison of Selected Design Related Physical Properties for the Different Collections

a) Moisture Contents

The mean values of moisture contents for the six collections were 7.42,15.63,8.18,13.89,9.73 and 14.15% with mean value and coefficient of variation of 11.5% and 27.65 as shown in 3.4 for Sammaz 32,36,28,29,17 and 33 respectively. The results showed that there high variability in moisture contents as the coefficient of variation is not within the acceptable range of) to 14%(Isiaka et al., 2006).

b) Thousand seeds Weight

The mean values of thousand seed weight for the six collections were 203.62g, 306.86g, 230.62g, 244.35g, 265.82g with a mean value and coefficient of variation of 241.9g and 18.89%.The results indicated that there were high variability in seedssizes as the coefficient of variation is not within the acceptable range.

c) Equivalent Diameter

The mean values of equivalent diameter for the six collections were 6.9mm, 7.1mm, 6.6mm, 7.2mm, 6.9mm and 7.2mm with a mean value and coefficient of variation of 6.9mm and 2.89% for Sammaz 32, 36, 28, 29, 17 and 33 respectively. There was less variability in the equivalent diameter as the coefficient of variation was within the acceptable range of 0 to 14% (Isiaka, et al., 2006).

d) Sphericity

The mean values of sphericity for the six collections were 76,72,81,70,71 and 62% within a mean value and coefficient of variation of 72% and 8.33% for Sammaz 32,36,28,29,17 and 33 respectively. There was less variability in the sphericity as the coefficient of variation was within the acceptable range of 0 to 14%.

e) Roundness

The mean values of roundness for the six collections were 75.88,57.12,82.32,46.07,69.50 and 55.66 with mean value and coefficient of variation of 64.43 and 19.55.The results showed that there were high variability in roundness as the coefficient of variation is not within the acceptable range.

3.5: Summary and Recommendation

3.5.1: Summary

Some selected design related physical properties of six selected Institute for Agricultural Research Improved Maize Varieties were investigated. Results indicated that the length, width, thickness, equivalent diameter, surface area, sphericity, roundness, bulk density, solid density, porosity, volume and angle of repose from 8.2mm to 10.4mm,7.1mm to 9.1mm,4.0mm to 5.0mm,6.6mm to 7.2mm,133mm^2 to 161mm^2, 62% to 81%, 55.66% to 82.32%, 692.42kg/m^3 to 737.18kg/m^3,1162.54kg/m^3 to 1447.7kg/m^3,37.79 to 46.69%170.09mm^3 to 225.19mm^3, 35.8^o to 44.8^o respectively for the six collections.

3.5.2: Recommendation

1- There is need for a more comprehensive research on properties of other varieties of maize, not included in this work and for other grains.
2- Mechanical and thermal properties need to be studied. This could assist in appropriate handling, processing and storage of maize crop for consumption and industrial usage.

IV. Conclusions

The following conclusion can be drawn from the study

1- The results revealed that there variations in few of physical properties determined indicating that differences in varieties are not important in equipment design and development.
2- The results of the study provide useful data that can be used to develop new equipment and also to upgrade the existing ones for handling, processing and storage of maize seeds found in Northwest ecological zone and other parts of Nigeria.

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