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Effects of variety and moisture content on some physical properties of okra pod

Adejumo A.O.D[1], Ajav E. A[2] and Igbeka J.C[2]
[1]Agricultural Engineering Department, Federal College of Agriculture, Ibadan.
[2]Agricultural and Environmental Engineering Department, University of Ibadan, Ibadan.

ABSTRACT*: Some physical properties of four varieties of okra pods NHAe47-4, LD88, V-35 and 'Elesoagbonrin' were determined at moisture content levels of 7, 14, 21 and 28 percent (wet basis) which are useful in the design of its processing, handling and storage equipment. The properties determined and mean values were length(107.97mm),diameter(35.17mm), mass(13.27g), true density(0.26g/cm^3), bulk density (0.18g/cm^3), porosity(58.06%), projected area(723.23mm^2), surface area(2627.55mm^2) and shape (conic/ribbed). The axial dimensions, individual pod mass, true and bulk densities increased as moisture content increases between 7 and 28% w.b. for the four varieties. The effect of moisture content was highly significant on the properties (p = 0.05).*

KEYWORDS: Okra, Pod, Physical Properties

I. INTRODUCTION

World production statistics for fruit and vegetable shows okra (abelmosus esculentus (l) moench) as the fourth main vegetable produced by India whom is ranked second in the world vegetable producer (Eipeson and bhowmik [1]. Okra can be found in almost every market in Africa. In Nigeria, okra is ranked second best vegetable in order of importance, in Ghana, it is the fourth most popular vegetable, in Cameroon, it is the second most important vegetable in the market after tomatoes, in Sudan, it is the third most popular vegetable (Ogungbaigbe [2] and Schippers [3].

Mohsenin [4], stated that Agricultural produce are subjected to various physical treatments involving mechanical, thermal, electrical, optical and sonic techniques and devices from the field to the consumer; therefore, it is essential to understand the physical laws governing the response of the crop so that machine, processes and handling operation can be designed for maximum efficiency and highest quality of the end product. The criterions used for describing shape and size includes charted standards, roundness, sphericity, measurement of axial dimensions, resemblance to geometric bodies and average projected area. He stated that sphericity of most agriculture produce is within the range of 0.32 to 1.00.

Visvanathan et. al. [5], determined the effect of moisture content (7.6-21 % w.b) on physical properties of Neem (Azadirachta India) nut. The diametral axis, porosity, bulk density and particle density decreased linearly but mass of 1000 nuts increased with increased moisture content. Waziri and Mittal [6], commended that Agricultural material pose special problems in determining their physical properties because of their diversity in shape, size, moisture content and maturity levels. Dutta et. al. [7], determined the dependence of physical properties of Gram on moisture content and obtained average 1000-grain weight of 0.173 kg, a mean surface area of 133.4 mm^2 and sphericity of 74 % at 10.9 % m.c db, bulk density and kernel density decreases in moisture range 9.64-31.0 % db.

Oje [8], carried out studies on locust bean pods and seeds physical properties relevant to dehulling and obtained the pods major diameter ranging from 76 to 277 mm and 8-12 m for the seeds. Adejumo et. al. [9, 10] studied the effects of moisture content and variety on frictional, aerodynamic, and selected mechanical properties of okra pod and observed that frictional and aerodynamic properties increased with increase in moisture content and varied among the varieties. Impact and compressive force, energy and young modulus deceased with increase in moisture content and also varied among the varieties. All the parameters were significant at 5% level.

II. MATERIALS AND METHODS

The initial moisture content of the four varieties of Okra NHAe47-4 and LD88 obtained from National Horticultural Research Institute, idi-shin, Ibadan; V-35 obtained from Institute of Agricultural Research and Training, Moor Plantation, Ibadan; and 'Elesoagbonrin'(Yoruba) were determined by the oven method ASAE Standards [11]. Methods developed by Visvanathan et. al. [5] were used for sample preparation to obtain desired moisture content.

2.1 Linear Dimensions

Shape and size are inseparable physical properties and are both generally necessary if an object is to be satisfactory described.

Thirty dry okra pods were randomly selected from each variety as samples. Plate 1 shows the dry okra pod samples. Two linear dimensions of each pod namely length and diameter were measured with a Vernier Caliper, reading to 0.01 cm. The shapes of pods were compared with the charted standards Moshsenin [12].

Okra pod surface area was determined by using a method adopted by Oje and Ugbor [13]. The pod surface was carefully coated in a light sensitive flexible paper. The surface edges on the paper were then pencil-traced on graph paper and the surface measured by counting the squares within the traced marks.

Plate 1. Okra Pod Samples

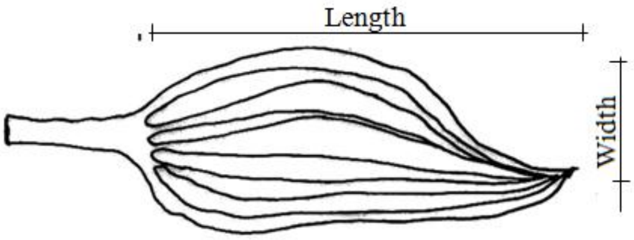

Fig.1: Linear Dimensions of Okra pod

2.1Gravinometric dimensions

The bulk density of dry okra pod at different moisture content was determined by filling a container (open top rectangular box of 200 x 100 x 100 mm) of known self-weight to the brim with dry okra pod and weighed to determine the net weight of the pod. Uniform density was achieved by tapping the container 10 times in the same manner in all measurements, the bulk density was calculated as:

$$\rho_b = \frac{w_s}{w_o} \quad (1)$$

Where P_b is bulk density (g/cm3), w_s is weight of sample (g) and w_o is volume occupied (cm^3)

The true or particle density of dry okra pod was determined by the water displacement method. Dry okra pod absorbs water easily, thus each pod was carefully wrap in a thin, light, sensitive flexible nylon paper and carefully immersed to disallow air spaces (Oje and Ugbor [13].

$$\rho_t = \frac{w_s}{w_d} \quad (2)$$

Where P_t is bulk density (g/cm3), w_s is weight of sample (g) and w_d is volume of water displaced (cm^3)

Porosity of dry okra pods were determined theoretically from bulk and true densities of pods using the relationship presented by Jain and Bal[14] as follows;

$$P_p = \frac{P_b}{1-P_t} \quad (3)$$

Where P_b is bulk density (g/cm^3), P_P is particle density (g/cm^3) and P_t is porosity (%).

2.3 Statistical experimental design and analysis

A – 2 x 4 factorial in completely Randomized Design, (CRD) experimental design was used with a total of 960 observations (4 variety x 4 moisture content levels x 30 samples) each for major diameters, length , bulk and true densities, porosity, surface area for pod respectively.

III. RESULTS AND DISCUSSION

Results obtained from the study are presented in Tables 1 to 7 and in Figures 2 to 6. The effect of moisture content (mc) on the pod length and diameter for the four varieties were as shown in Tables 1 to 4. It was observed that the pod length and diameter increased with increase in moisture content. There is significant difference in the mean of pod length from 7 to 28 % moisture content at 5% significant level. Pod length of variety NHAe47-4 increased from 104.01 to 105.35 mm, V-35 from 89. 59 mm to 89.64 mm, LD88 from 89.27 to 90.28 mm and 'Elesoagbonrin' from 127.59 to 129.63 mm while the diameter increased from 46.17 to 48.54 mm, 27.37 to 37.33 mm, 32.01 to 34.28 mm and 27.37 to 28.48 mm for the varieties respectively. The grand mean pod length was 103.18 mm while that of the diameter was 36.20 mm. The relationships among the dimensions and moisture content were logarithmic with R^2 0.52 – 0.99 as presented in Figures 2 and 3.

The results as presented in Tables 2 and 3 showed that as dry okra pod absolves water, it increases radial rather than axial due to the swollen effect which is radial. 'Elesoagbonrin' gave the highest pod length (128.67 mm) and LD88 gave the least (89.78 mm). NHAe47-4 gave the highest diameter (47.23 mm) and 'Elesoagbonrin' the least (27.96 mm).

The results are similar to those reported for okra by Adejumo [9] but not in accordance with that of Visvanathan[5]for Neem (Azadirachta India) nut. The shape of okra pod is regarded as conic /ribbed as compared with the charted standards (Mohsenin [12]. It tapers towards the apex and the cross section is more or less angular. The overall mean length and diameter are 107.97mm and 35.17mm respectively.

Processing, handling and storage were affected by size and shape of okra pod. The size of the pod determined the size and orientation of the hopper seat, which directs the product into the threshing chamber and the adjustment of the concave clearance. If the inlet and the concave clearance are small, the pods get choked in the hopper and the seed could be crushed on the cylinder

The information on the interaction between okra varieties and moisture content (Table 4) is necessary in knowing whether a concave clearance and a screen specified for one variety at a given moisture content can be used for another at the same or different moisture content, thus reducing the number of threshing drums and screens in processing the four varieties in the moisture content range of 7 to 28 %.

The true (particle) density of okra pod generally increased with increase in moisture content. NHAe47-4 decreased from 0.21 g/cm^3 at 7 % to 0.19 g/cm^3 at 14 % then increased to 0.21 at 28 % moisture content, V-35 increased from 0.21 g/cm^3 to 0.33 g/cm^3; LD88 decreased from 0.27 g/cm^3 at 7% to 0.25 g/cm^3 at 14 % then increased to 0.3 g/cm^3 at 28 % moisture content and 'Elesoagbonrin' increased from 0.29 to 0.3 g/cm^3.

TABLE 1: OVERALL AVERAGE OF SOME PHYSICAL PROPERTIES OF OKRA POD

	length (mm)	Diameter (mm)	Mass (g)	True Density (g/cm^3)	Bulk Density (g/cm^3)	Porosity (%)
Means	107.97	35.17	13.27	0.26	0.14	58.06
Std. dev.	17.65	7.97	4.07	0.12	0.02	27.66
Minimum	78	24.5	3.13	0.08	0.10	17.16
Maximum	136	54	25.43	0.27	0.19	91.97

95% confidence interval

TABLE 2: MOISTURE CONTENT EFFECT ON SOME PHYSICAL PROPERTIES OF OKRA POD

Moisture Content	Length (mm)	Diameter (mm)	Mass (g)	**True Density** (g/cm^3)	**Bulk Density** (g/cm^3)	**Porosity** (%)
7%	112.45^A	33.35^B	12.08^c	0.24^B	0.13^C	59.20^A
14%	112.96^A	33.69^B	12.78^{bc}	0.24^B	0.13^C	58.83^A
21%	103.27^B	3646^A	13.66^{ab}	0.25^{AB}	0.14^B	58.21^A
28%	103.20^B	37.16^A	14.56^a	0.29^A	0.15^A	55.92^A
LSD	4.44	2.04	1.02	0.02	0.004	0.07

TABLE 3: VARIETY EFFECT ON SOME PHYSICAL PROPERTIES OF OKRA PODS

Variety	Length (mm)	Diameter (mm)	Mass (g)	True Density (g/cm^3)	Bulk Density (g/cm^3)	Porosity (%)
NHAE 474	104.67 B	47.23^A	19.10^A	0.20^C	0.12$^{B\ A}$	40.51C
V-35	98.10^C	32.31^B	11.16^C	0.25^B	0.16^A	74.32A
LD 88	89.78^D	33.16^B	10.50^D	0.28^{AB}	0.15^B	72.39AB
'Elesoagbonrin'	128.69 A	27.96^D	12.32^B	0.30^A	0.14^C	69.95B
LSD	2.50	0.73	0.51	0.014	0.002	3.00

TABLE 4: ANALYSIS OF VARIANCE FOR SOME PHYSICAL PROPERTIES OF OKRA POD.

Source of Variance	df	Length (mm)	Diameter (mm)	Mass (g)	True Density (g/cm^3)	Buk Density (g/cm^3)	Porosity (%)
M.c	3	11.71***	6.91***	8.56***	2.88*	51.69***	0.82 NS
Variety	3	318.67***	1019.45***	471.55***	15.11***	646.5***	711.41***
Mc x Variety	15	393.82***	409.01***	114.16***	4.55***	383.34***	149.65***
Error	442						
Total	474						

* = significantly different at 5%, * * = significantly different at1% ,*** = significantly different at 0.1%,ns = not significantly different

TABLE 5: POD PROJECTED AND SURFACE AREAS

Item	Means	Std Error	Lower Bound	Upper bound
Pod Project Area(mm^2)				
Nhae47-4	1033.10^a	23.31	985.83	1080.37
V-35	622.80^{bc}	23.31	595.53	670.07
Ld88	556.70^c	23.31	509.43	630.97
'Elesoagbonrin'	680.30^b	23.31	633.03	727.57
Overall Average	723.23	11.65	699.59	746.86
Pod Surface Area(mm^2)				
Nhae47-4	3615.70^a	85.54	3442.22	3789.18
V-35	2269.60^c	85.54	2096.12	2443.08
Ld88	2032.20^c	85.54	1858.72	2265.68
'Elesoagbonrin'	2592.70	85.54	2419.22	2766.18
Overall Average	2627.55	42.77	2540.81	2714.29

10% Moisture Content. 95% Confidence Interval.

TABLE 6: ANALYSIS OF VARIANCE FOR POD PROJECT AND SURFACE AREAS

Source of Variance	Df	Pod Projected Area (mm^2)	Pod Surface Area (mm^2)
Variety	3	83.252*	66.520*
Error	36		
Total	39		

* = Significantly different at 5%

TABLE 7: SEED/CHAFF RATIO

Rep	1	2	3	Average
NHAe47-4	1.33	1.33	1.33	1.33
V-35	1.31	0.99	1.58	1.29
LD88	2.00	1.71	2.53	2.08
'Elesoagbonrin'	1.29	1.21	1.35	1.31
Average				1.50

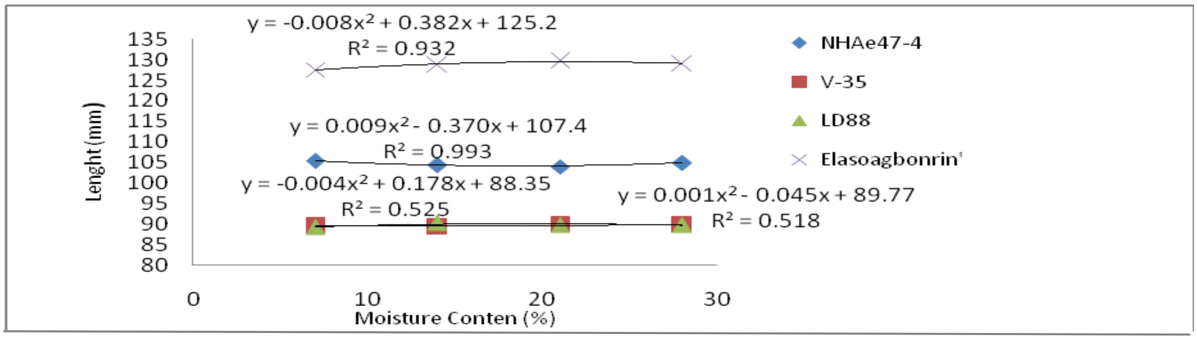

Fig.2: Effect of Moisture Content on Okra Pod Length

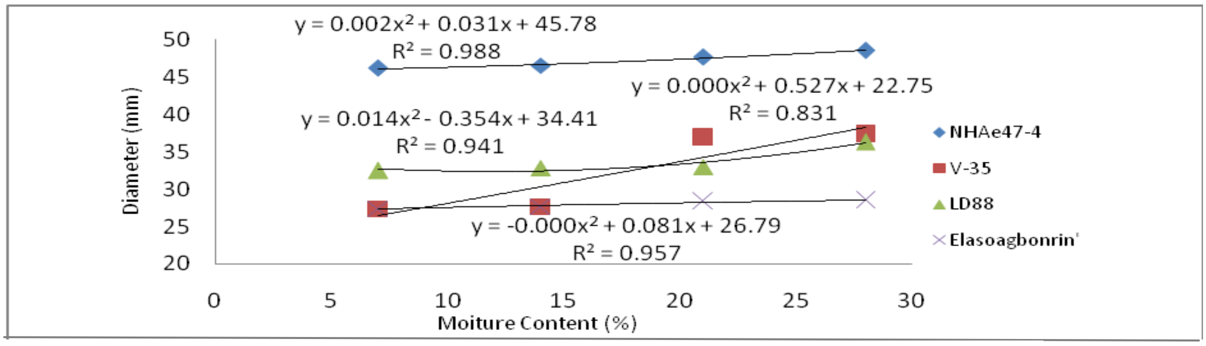

Fig.3: Effect of Moisture Content on Okra Pod Diameter

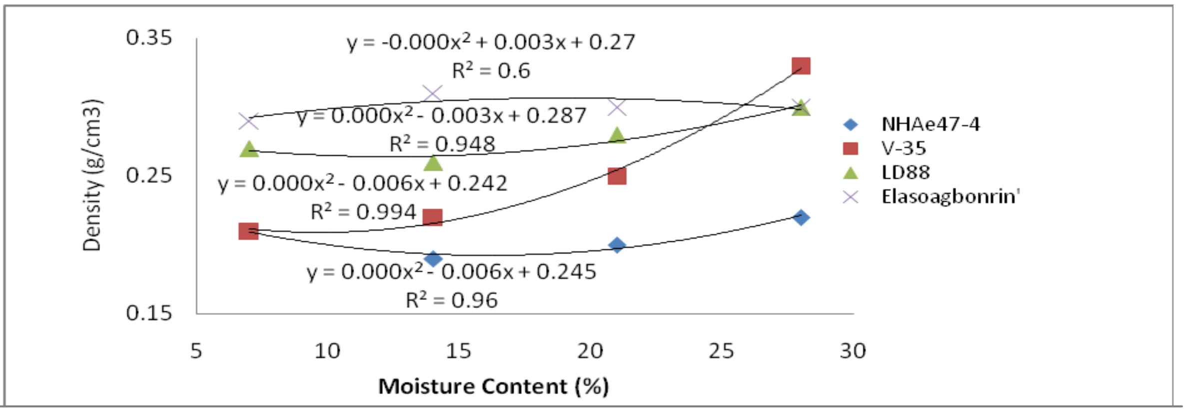

Fig.4: Effect of Moisture Content on True Density of Okra Pod

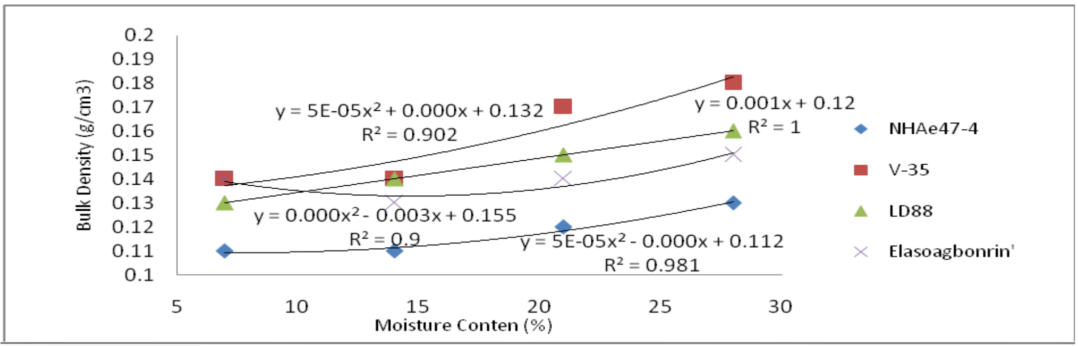

Fig.5: Effect of Moisture Content on Bulk Density of Okra Pod

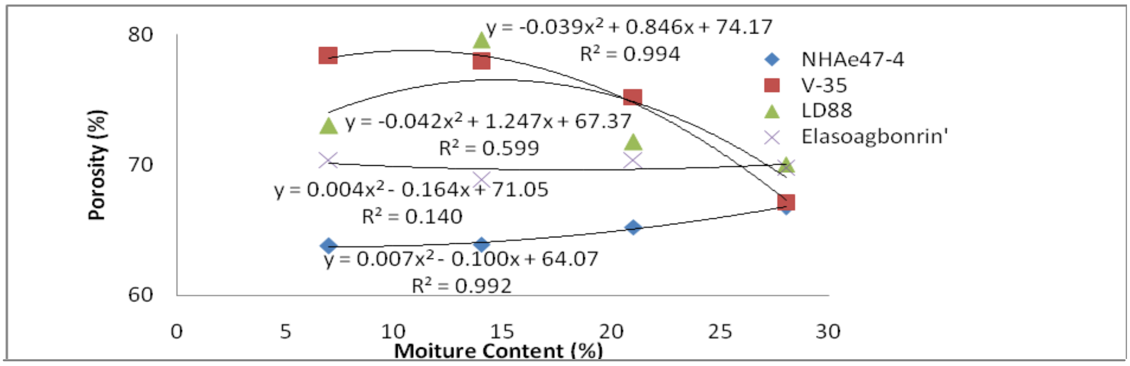

Fig.6: Effect of Moisture Content on Porosity of Okra Pod

Bulk densities of pods increased with increase in moisture content. NHAe47-4 pod density increased from 0.11 to 0.13 g/cm^3, V-35 pod increased from 0.14 to 0.18 g/cm^3, LD88 pod increased 0.12to 0.16 g/cm^3 and 'Elesoagbonrin' pod increased from 0.14 to 0.15 g/cm^3 at 7 to 28 % moisture content respectively. All relationships among the dimensions are logrimic as expressed in Figure 4 and 5. There is no difference between means of pod true density at 7 to 21 % moisture content (Tables 2 and 3).

The true density of okra pod generally increases with increase in moisture content in accordance with results obtained for frictional and aerodynamic properties Adejumo [9], but not in agreement with those of Visvanathan et. al. [5] and Dutta [7] for Neem (Azadirachta India) nut and gram respectively. The results suggest that the pod increase in weight does not commensurate with volume increase as the moisture content increases. This is due to the fibrous nature of the pod, which absorbs the moisture with little swell in size. Pod true density is in the range of 0.25 to 0.26 g/cm^3 for the moisture content range of 7 to 28 % (w.b). Increase in pod bulk densities with moisture content suggests that increase in the mass of pod out-weigh the volume. Thus, the increase in bulk volume of pod is negligible.

The analysis of variance (Table 4) shows that there is a significant difference in moisture content effect on the pod true and bulk densities at 5% level. Likewise the varietals effect on pod true and bulk densities are significantly different at 5 % level. The interaction between variety and moisture content are also significant except for the pod true density. The true and bulk densities of pod are in the range 0.14 - 0.26 g/cm^3.

In agricultural produce processing, the true and bulk densities are of important practical application. The knowledge of density is useful in the design of silos and storage bins, processing and handling machines, maturity and quality evaluation of products, which are essential in grain marketing. Others include determination of Reynolds number, thermal properties in heat transfer problems, chemical composition, separation of products by flotation etc.

The effects of moisture content on okra pod porosities are as shown in Figure 6. The porosity of NHAe47-4 pod decreased from 47.8 % at 7 % moisture content to 36.1 % at 14 % and increase to 36.6 % at 28 % moisture content. The porosity of V-35 pod increased from 29.5 % at 7 % moisture content to 36.6 at 14 % moisture content, and decreased to 26.4 % at 28 % moisture content. LD88 pod decreased from 48.7 % at 7 % moisture content to 43 % at 14 % moisture content and increased to 46.3 % at 28 % moisture content. 'Elesoagbonrin' pod increased from 51 % at 7 % moisture content to 54.9 % at 14 % and decreased to 51.3 % at 28 % moisture content. There are no significant difference (5 % level) between means of pod porosity at 7 to 28 % moisture content (Tables 2, 3 and 4).

The variation in the porosity of okra pod is in two groups. NHAe47-4 and LD88 decreased to a minimum in the range 14 –21 % moisture content and increased thereafter, while V-35 and 'Elesoagbonrin' increased to maximum in the same moisture content range and decrease thereafter as moisture content increased from 7 to 28 %(w.b). Analysis of variance shows that the effects of moisture contents on porosity of okra pod are not significant unlike variety and their interactions at 5 % level.

The utilization of okra pod porosity can be seen in the area of drying (heat and air flow), storage and aeration, bagging and marketing of seed and design of processing and plant machinery.

The results of okra pod projected and surface areas at 10 % moisture content and mass of pod (7 to 28 % moisture content) are presented in Table 5. Analysis of variance is presented in Table 6.

The projected area of Okra pod varied with the variety with grand mean of 723.23 mm^2. Pod projected area are: 1033.10 mm^2, 622.80 mm^2, 556.70 mm^2 and 680.30 mm^2; and pod surface area are 3615.70 mm^2, 2269.60 mm^2, 2032.20 mm^2 and 2592.70 mm^2 for the four varieties respectively (NHAe47-4, V.35, LD88 and 'Elesoagbonrin'). There is no difference between means of V-35 and LD88 pod surface area with a grand mean of 2627.55 mm^2 for the four studied varieties. Okra seed/chaff ratio ranges from 0.99 to 2.53 with mean of 1.50 (Table 7).

The mass of pod increases with increase in moisture content. This is because the absorbed water increases the self-weight of the pod. Tables 1 to 4 show that there is no significant different between means of V-35 and LD88 mass of pod. The mass of pod is significant at 5 % on moisture content levels and among the varieties. The mean value of mass of pod was 19.10 g for NHAe47-4, 11.16 g for V-35, 10.50 g for LD88 and 12.32 g for 'Elesoagbonrin'. The grand mean value was 13.30 g at moisture content of 7 to 28 %.

The analysis of variance shows that the means of the pod projected and surface area are significantly different among the variety at 5 % level. NHAe47-4 gave the highest projected area and LD88 the least projected area, NHAE47-4 gave the largest surface area, followed by 'Elesoagbonrin' then V-35 which is not significantly different from LD88.Variation in the parameters are due to diversity of agricultural material properties in agreement with Waziri and Mittal [6],who state that agricultural materials pose special problems in determining their physical properties.

The projected and surface areas are usefully in obtaining the drag force, design of storage bin, processing and handling equipment of Okra pod.

IV. CONCLUSION

From the results obtained in this study, the following conclusions were drawn;

i The linear dimensions of pod, equivalent diameter, true and bulk density of pod increases with increase in moisture content.

ii The four Okra varieties (NHAe47-4, V-35, LD88 and 'Elesoagbonrin') pods were different with respect to linear dimensions, equivalent diameter, number of seed per pod, pod projected area, pod surface area, true and bulk densities and porosity.

iii The mean Okra pod length and diameter were 107.97 mm and 35.17 mm regarded as conic/ribbed during the analysis of rate processes.

iv The true densities of Okra pod were higher than the bulk densities with ranges 0.25 – 0.27 g/cm^3 (true) and 0.10 – 0.19 g/cm^3 (bulk).

v The mean Okra pod projected area was 723.23 mm^2 and pod surface area was 2627.55 mm^2. These parameters varied significantly with the varieties.

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