SOME ENGINEERING PROPERTIES OF PROSOPIS AFRICANA PODS RELEVANT TO DEHULLING

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ABSTRACT
Some physical and rheological characteristics of *prosopis africana* pods that are pertinent to post-harvest technology were determined. The results obtained indicated that the pods have major diameter ranging from 55mm to 200mm while the geometric mean diameter ranges between 41 mm and 63mm. The values obtained for the density revealed that it could be separated from other agricultural materials that are heavier than water by flotation method. The results obtained further revealed that the energy required to get the seeds from the pods is considerably greater when cracked along its major axis than cracking the pod along its intermediate or minor axis.

Key words: *Prosopis africana*, pods, processing

1. INTRODUCTION

Prosopis africana plant is a tropical leguminous tree that is readily distinguished by its dark, pale drooping foliage with small pointed leaflets. The tree is about 12m to 18m high and up to 2.2m in girth. The dry pods which are between 10cm and 15cm long and about 2cm thick contain numerous ellipsoid seeds of about 15 to 18. The only known usage of these seeds, presently in Nigeria, is as food seasoning, which is particularly common among the Idomas of Benue State. The seeds are processed in the same way as locust bean seeds. The seeds have protein content of between 39 and 40 per cent *[1]*. *Prosopis africana* seeds now represent an economic hope for a vast semi-arid region in Brazil [2]. Therefore, the mechanization of its processing has generated lots of interest in the recent time. To actualize its mechanization, it is therefore, necessary to establish some of its prominent engineering properties.

Several researchers [3, 4, 5, 6] have described sizes of different crops they worked with by measuring their three principal dimensions (i.e major intermediate and minor diameters). Sphericity (volume shape factor) for gram was determined by drawing of shadow graph of its samples; the diameters of various inscribed and circumscribed circles of the projected areas were then measured [5]. The sphericity was later computed using standard equation [7]. In attempt to establish the sphericity of the gram 20 samples at the same moisture content were randomly selected for the procedure.

The volume of different agricultural crops have been measured using water displacement method [7,8]. Some rheological properties for processed apple were obtained by using the force-deformation relationship curve [9.10].

2. Material and Methods

Over 5000 mature pods were gathered from basal areas of different parent plants from different locations. Harvesting was done when the local processors were equally scrabbing for the seeds; which affirmed the time local processing takes place. At that juncture the moisture content was determined to be 13.52 cent dry basis using oven dry method [11]

One hundred pods were randomly selected from the sample at a time for each property determination. Measurement of dimensions on the three mutually perpendicular axes (major. intermediate and minor diameters) was done using vernier calliper. Sphericity of the pods were determined by placing each pod in its natural resting position on a sheet of graph paper. A sharp thin pencil was then used to carefully trace the edges of the pod. The projected area and diameter of various inscribed and circumscribed circles were measured and used to arrive at the pod sphericity.

The volume of each of the pod sampled was determined by water displacement method. The pod was immersed into a measuring Can filled with water. The volume of water displaced was used to arrive at the volume of the pod; while the densities of the pods were computed mathematically [6, 7].

The static coefficient of friction for the pods with respect to four structural surfaces (plywood with its grain parallel and perpendicular to the direction of motion of the materials; galvanized steel and glass) [6]. A topless and bottomless box of 150 x 100 X 40mm dimensions was flied with the pods and placed on an adjustable tilting surface. One end of this surface with the box resting on it was raised gradually with a screw device, until the box just started to slide down. The angle of inclination was read from a graduated scale. This procedure was repeated in turn for each surface mentioned above.

The compression tests were carried out on Monsanto Tensiometer "Type W" under a compression arrangement. An X- Y chart was calibrated and attached onto the plastic drum of the tensiometer. Each of the 30 replicates randomly selected was placed between the compression plates of the tensiometer. The drive wheel was smoothly driven to gradually apply the load on the positioned material while the chart on the plastic drum was simultaneously plotted. Each process was often terminated whenever bioyield point of the material was reached because the fluid of the measuring device dropped automatically.

3. Results and Discussion

The results obtained as well as frequency distribution curves for some of the properties determined for *prosopis africana* pods are shown in Tables 1 and 2 and, figures I and 2 respectively.

The mass of the pods ranges between 10g and 36g (Table I). About 70% of the pods falls between 20.0g and 29.9g. (Figure 1). The distribution of the mass is close to the normal. The major diameter ranges between 55.6mm and 200.0mm while intermediate ranges between 21.0mm and 39.0 and minor diameter is between 15.0mm and 22.0mm. The frequency distribution curves for the major and intermediate diameters are skewed to the left of the normal while that of the minor diameter is close to the normal (Figure 1).

The mean value for the pod's density and volume are 0.47gm/cm^3 and 53.43cm^3 respectively. This value is an indication that the pod will not sink in water. The density has a range of values between 0.36g/cm^3 and O.6g/cm^3 while the volume has a range of values between 20.0 and 85.0cm^3 (Table I). Figure 1 shows that both the density and volume have distribution curves close to the normal.

The static coefficient of friction for the pods on the four different planes have a maximum value of 34 degrees on plywood with grains parallel to sliding direction and maximum value 41 degrees on plywood with grains perpendicular to sliding direction, while the mean value obtained for galvanized and glass are 35.2 and 34.6 degrees respectively.

The results presented in Table 2 summarized the values obtained for some rheological properties of the pods. Figure 2 shows the corresponding frequency distribution curves. It was observed that the force required to crack the pods was higher when cracked axially than when cracked laterally. Apart from rupture force frequency distribution curve that is bi-modal of normal distribution

other properties frequency distribution curves are quite close to the normal distribution.
The investigation revealed the following:

(a) the frequency distributions of most properties for *prosopis Africana* pods approach the normal distribution.
(b) the mass and principal dimensions of the pods vary widely
(c) the pod is lighter and cannot sink in water. This established fact could be used in separating the pods from other agricultural materials that are heavier than water;
(d) the hopper and other unloading devices for handling the pod must be built fairly steep with angle of inclination between 30 and 40 degrees because of the high coefficient friction observed for the pod
(e) the force required to break the pods varies widely in either of the axes, this point must be taken into cognizance when developing a cracking machine for the pods.

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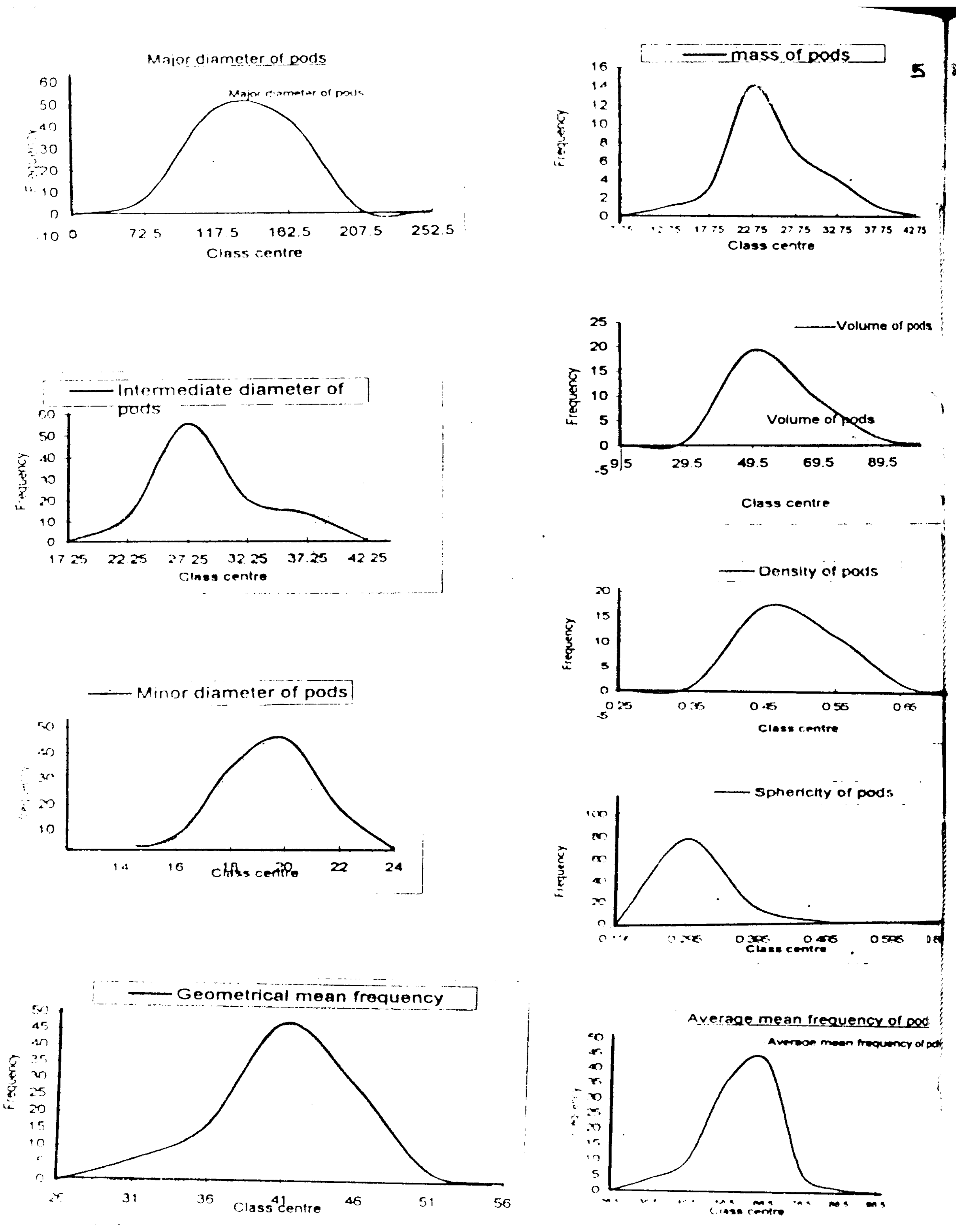
Table 1: some physical properties of the pods of prosopis Africana at 13.52%.m.c.db.

Property/unit of measurement	No of trials	Mean value	Stand Dev	Maximum value	Minimum value
Mass (g)	30	24.72	4.96	36.00	10.00
Major diameter(mm)	100	132.47	26.49	2000.00	55.60
Intermediate diameter (mm)	100	28.71	4.04	39.00	21.00
Minor diameter (mm)	100	19.00	1.74	22.00	32.47
Geometrical mean dia .(mm)	100	41.39	1.41	52.56	0.25
Average diameter (mm)	100	60.04	9.32	85.00	20.00
Sphericity	100	0.32	0.06	0.06	0.36
Volume (cm^3)	30	53.43	13.20	85.00	32.47
Density (g/m^3)	30	0.47	0.06	0.06	0.25
Coefficient of friction					
a. plywood with grians/to sliding direction (deg)	10	33.17	1.12	34.00	30.00
b. plywood with grain-to silding direction (deg)	10	40.10	0.97	41.00	38.00
c. galvanized steel (deg)	10	35.20	0.78	36.50	34.00
d glass (deg)	10	34.55	0.76	35.00	33.00

Table 2: Some rheological properties of the pods of prosopis Africana at 13.52% m.c.db

Unity of measurement	orientation	No of trials	Mean value	Stand deviation	Maximum value	Minimum value
Rupture force (KN)	Major	30	0.394	0.096	0.600	0.200
Deformation (mm)	Major	30	2.059	0.564	3.190	1.020
Bio-yield force (KN)	Major	30	0.213	0.063	0.400	0.100
Deformation (mm)	Major	30	0.967	0.416	1.790	0.260
Rapture force (KN)	Major	30	0.411	0.167	0.834	0.123
Bio-yield energy (X 10^{-3}) (K)	Major	30	0.104	0.056	0.218	0.038
Rapture force (KN)	Intermediate	30	0.435	0.132	0.730	0.230
Deformation (mm)	Intermediate		2.627	0.627	4.230	1.080
Bio-yield force (KN)	Intermediate	30	0.079	0.079	0.460	0.120
Rupture energy (X 10^{-3})(KJ)	Intermediate	30	0.602	0.265	1.287	0.124
Bio-yield energy (X 10^{-3}) (KJ)	Intermediate	30	0.171	0.074	0.387	0.045
Rupture force (KN)	Minor	30	0.386	0.086	0.516	0.186
Deformation (mm)	Minor	30	1.967	0.416	1.790	0.260
Bio-yield (KW)	Minor	30	0.209	0.073	0.356	0.098
Rupture energy (X 10^{-3}) K	Minor	30	0.407	0.083	0.658	0.120
Bio-yield energy (X 10^{-3}) k	Minor	30	0.096	0.0421	0.118	0.058



igure 1. Distribution curves for some physical properties of prosopis *Africana* pods.

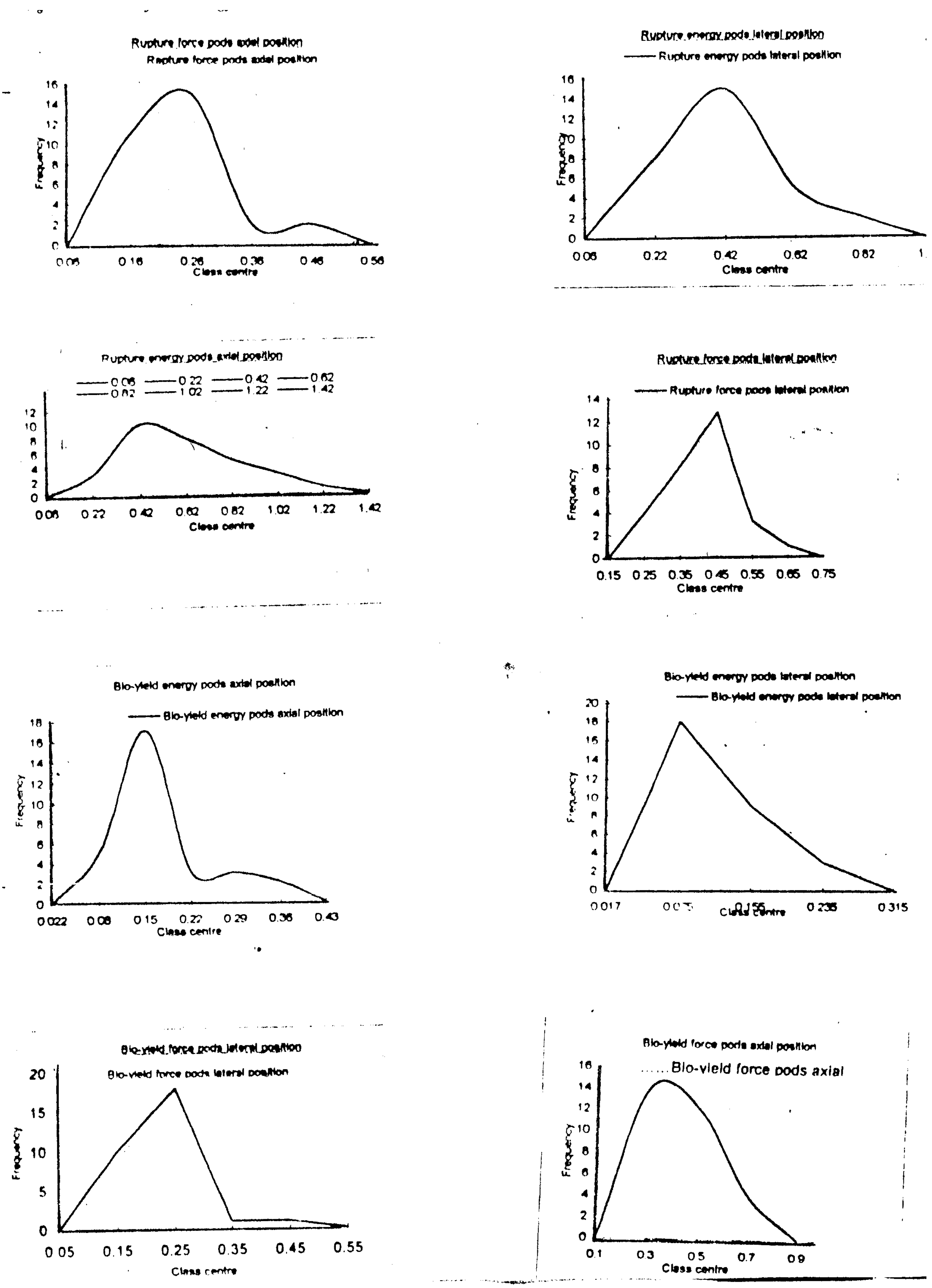


Figure 2. Distribution curves for some rheological properties of *prosopis Africana* pods.