SOME ENGINEERING PROPERTIES OF GROUNDNUT FOR THE DESIGN AND DEVELOPMENT OF GROUNDNUT DECORTICATOR

ABSTRACT

The important physical properties which effect the battery-operated groundnut decorticator were size (length and width) of kernels,size (length, width and thickness), 1000 pod mass, bulk density, angle of repose, moisture content and rupture force of groundnut pod. It was observed that the average length of pod was30.84, 28.02 and 36.8 mm, average width of pod was 12.01, 12.59 and 14.33 mm and average thickness of pod was 10.79, 10.91 and 14.31 mm for variety 1, 2 and 3 respectively. The average length of kernels was 16.68, 19.28and 18.7 mm and average width of kernels was 11.59,9.08, 8 mm for variety 1, 2 and 3 respectively. The bulk densities groundnut pods were found to have an average value of 0.36 g/cm^3, 0.35 g/cm^3 and 0.26 g/cm^3 for variety1, 2, 3 respectively. The average angle of repose values for variety 1, 2 and3 was 26.59° and 26.54° and 24.22°. The average values of moisture content were found to have 5.37, 4.52and 4.5% for variety 1, 2 and 3 was respectively. The average values of rupture force for variety 1 was 237.61N, variety 2 was 231.01 N and for variety 3 was 337.86N.

Key words: Groundnut, Pod, Kernel, Physical Properties and Decorticator.

1.INTRODUCTION

Groundnut or peanut (*Arachis Hypogaea Linn*) is commonly called the poor man's nut. It is an important oil seed and food crop (APEDA, 2018). The whole pod is frequently referred to as a monkey nut. According to studies by Jambunathanet al 1985, groundnut seeds (kernels) contain 35.8–54.2% oil, 16.2-36.0% protein, and 10–20% carbohydrates. The seeds are also a good

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1.Engineering Properties of Groundnut for Designing a Battery-Operated Decorticator
2.Key Engineering Properties for Designing Groundnut Decorticators
3.Essential Groundnut Properties for Decorticator Development

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source of vitamins E, niacin, folacin, riboflavin, and thiamine, as well as minerals including calcium, phosphorus, and iron. Haulms of groundnuts are a wholesome source of feed for animals. They have larger concentrations of protein (8–15%), fats (1-3%), minerals (9–17%), and carbohydrates (38–45%) than cereal fodders. Animals digestibility of crude protein is 88% and that of nutrients in groundnut haulm is approximately 53% (Nagaraj 1988).

Physical properties of groundnut play a significant role in handling, processing and storage of agricultural commodities.The knowledge of physical properties of biological material gives a basis for the design and selection of appropriate equipment for post-harvest operations. Groundnut decorticator, also called shell removers and skin separator, is the machine used for stripping the skin or hulls of seeds. Groundnut decorticator is especially to crack outer shell of groundnut pods for getting kernel. In Indian farm, many groundnut decorticators are used.The selection and design of groundnut decorticating machines is directly related to physical properties of groundnut.

Determination of physical properties such as size of pod and kernels, moisture content, angle of repose, bulk density, 1000 pod weight and rupture force of pod were required for the design of various machine parts. The purpose of this study was to determine the physical properties of groundnut and select the most significant values for the design and development of battery-operated groundnut decorticator.

2. MATERIAL AND METHODS

The experiments were carried out in Energy Laboratory of Division of Agricultural Engineering, ICAR-Indian Agricultural Research Institute (IARI), New Delhi. As our aim is to make the decorticator more robust and flexible, we randomly bought three different varieties of groundnut pods from local market of New Delhi and were named as variety 1, 2 and 3. The

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physical properties of these three varieties were determined and the methodology is described in the further section of this paper.The major objective of conducting this study was to find the significant values of each physical property for the design and development of battery-operated groundnut decorticator. The plan of experiment to studythe physical properties of groundnut pod was given in Table 1.

Table 1: Experimental plan to study the physical properties of groundnut varieties

Parameters (Independent variables)	**Levels**	**Parameters (Dependent variables/ performance parameters)**
Varities of pod	3	• Size
Replication	3	• Bulk density
Total number of experiments	9	• 1000 pods weight • Angle of repose • Moisture content • Rupture force

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2.1 Determination of size of groundnut pods and seeds

Size (length and width) of kernels, size (length, width and thickness) of three different varieties of groundnut were measured using a digital vernier caliper (L.C: 1mm, length: 150mm). Twenty samples from one hundred groundnut pods were selected randomly from a bulk quantity of groundnut pods. Length, width and thickness were measured by holding each groundnut pod and

kernel with the help of vernier caliper (Fig.1 and Fig.2). The size measurement of groundnut pods and kernels were replicated three times and the observed values were recorded in datasheet (Appendix A.1 and A.2).

Fig.1: Measurement of size of groundnut pods

Fig.2: Measurement of size of groundnut kernels

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2.2 Determination of 1000 pod mass

The 1000 pod mass gives a substantial knowledge in calculating variety of grain holding units i.e., hopper. A one kilogram of groundnut pods was taken and divided into 10 equal portions. Three replications were made to get average value of 1000 pod mass (Appendix A.3).. The thousand pod mass was randomly selected from each portion and weighed separately using a digital electronic balance (Balasubramanian et al 2011).

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2.3 Determination of bulk density of groundnut pods

The knowledge of bulk density is useful for the design of hopper to determine the weight of agricultural products that will be held by these containers(Nalladurai et al 2002). The bulk density is determined by finding the mass/volume relationship (Fig.3). First an empty cylindrical container (9cm diameter and 11.8cm height) of predetermined volume was taken. Container is

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kept on the digital weighing balance (10 kg and L.C. 0.1g) and the container weight is tarred. Bulk of groundnut pods were poured into the container up to a constant height and top of container is labeled off and weighed on same digital balance. Bulk density is calculated by following relationship and given in Appendix A.4.

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$$\rho = \frac{M}{V} \text{ ----------(1)}$$

where,

ρ - bulk density (kg/m^3)

M - weight of pods (kg)

V - volume of container (m^3)

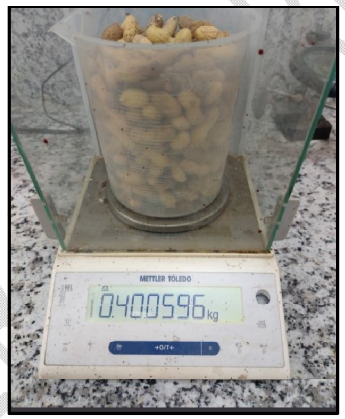

Fig.3: Weighing of groundnut pods for finding bulk density

2.4 Determination of angle of repose of groundnut pods

Angle of repose is the angle between the base and the slope of cone formed on a vertical fall of the granular material to a horizontal plane. The values of angle of repose of groundnut pods were useful in determining the angle of inclination of the feeding chute. A cylinder of diameter 148mm and 300mm height was taken for measuring angle of repose. The cylinder was open from both

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sides. The cylinder was kept on a plane horizontal surface and it was filled with groundnut pods. After that cylinder was gently lifted up above the flat surface and it was continued gradually until all the groundnut pods formed a conical heap on the surface (Fig.4). This procedure was repeated five times and recorded in data sheet. Angle of repose Θ_f is calculated by the equation 2 and given in Appendix A.5.

$$\Theta_f = \tan^{-1}\left(\frac{2H}{D}\right) \text{----------(2)}$$

Where,

Θ_f = Angle of repose, degrees

H = Height of heap, mm

D = Diameter of heap, mm

Fig.4: Determination of angle of repose of groundnut pods

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2.5 Determination of moisture content of groundnut pods

Moisture content of groundnut pod refers to the amount of water contained in the pod. A groundnut decorticator consumes more energy in breaking the pods and will lead to crush the seeds when the moisture content is high. Therefore, before shelling, it is desirable to dry them sufficiently. The moisture content of groundnut pods was determined using the oven method. The

initial weights of samples were determined using the digital electric balance. Three samples were dried in convection air oven which is set at temperature of 105°C and monitored over a period of 24 h at 6h intervals until the weights of the samples were found to be constant. The moisture content (wet basis) was calculated as the weight of moisture (initial weight minus final weight of sample) divide by the initial weight of sample and expressed in percentage. The values were provided in Appendix A.6. The formula employed in the process according to Sahay and Singh (1996) is as follows (equation 3):

$$MC(wb)=\frac{M1-M2}{M1-M3}\times 100 \text{----------(3}$$

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Where,

M1 = Weight of the wet sample, g

M2 = Weight of the dry sample, g

M3 = Weight of the moisture can, g

2.6 Determination of rupture force for groundnut pods

Rupture force indicates the minimum force which is required to break the groundnut pods and it must be exceeded to separate the kernel from the pod. This property is very important parameter in designing of equipment for shelling, milling, handling, storage, transportation. Insufficient data on this property leads to mechanical damage to pods in decortication operations which cause reduction in germination power and viability of seeds. The individual sample from three varietys of groundnut pods was loaded in Texture Analyzer each time and compressed at a loading speed of 2mm/s until fracture occur (Fig.5). This was replicated five times to get an average rupture force. Data of rupture force are given in Appendix A.7. On seeing the initial crack, the loading was stopped. Thus, the rupture force and deformation at rupture point were displayed on a

computer attached with a Texture Analyzer automatically. This experiment was conducted at the Division of Post Harvest Technology of the Institute.

Fig.5: Determination of rupture force of groundnut pod on Texture analyzer

3. RESULTS AND DISCUSSION

3.1 Size of groundnut pods

The average length of variety 1, variety 2 and variety 3 groundnut pods were 30.84, 28.02 and 36.8 mm, respectively (Table 2). The mean width of groundnut pods of variety 1, 2 and 3 were 12.01, 12.95 and 14.33 mm, respectively. The mean thickness of groundnut pods of variety 1, 2 and 3 were 10.79, 10.91 and 14.31 mm respectively. Among the width and thickness values, the highest value was selected for keeping the clearance between decorticating shoe and bottom sieve that was kept as 12 mm for variety 1, 13 mm for variety 2 and 14 mm for variety 3. The length helped in deciding the length of sieve opening. Both width and thickness helped in deciding the concave clearance between the decorticating shoes and sieve as reported by Maduako and Hamman (2004). All the values of length, width and thickness of groundnut pods of variety 1, 2 and 3are given in Appendix-A.1.

3.2 Size of groundnut kernels

The mean length of groundnut kernels of variety 1, 2 and 3 were 16.68, 19.28 and 18.70 respectively which is given in Table 3. Correspondingly, the width of groundnut kernels was 9.08, 8.00 and 11.59, mm. The width of rectangular sieve was decided based on the mean width value of groundnut kernels.It was observed that the size (length and width) of kernel is significant factor for determining the width of rectangular sieve because it was also seen that low kernel size was obtained with greater size of groundnut pods.

Table 2: Mean values of groundnut pods dimensions

Dimensions	Number of samples	Dimensions of different variety of groundnut pods, mm					
		Varieties					
		1		2		3	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Length	20	30.84	3.74	28.02	6.62	36.8	3.1
Width	20	12.01	0.91	12.95	0.87	14.33	0.59
Thickness	20	10.79	0.85	10.91	0.92	14.31	0.69

Therefore, width of rectangular sieve was taken.The length and width of kernels helped in deciding the width of sieve opening [7].The length and width of kernels of variety 1, 2 and 3 are given in Appendix-A.2.

Table 3: Mean values of groundnut kernels dimensions

Dimensions	Number of samples	Dimensions of different variety of groundnut kernels, mm					
		Varieties					
		1		2		3	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Length	20	16.68	1.95	19.28	1.92	18.70	1.60
Width	20	9.08	0.48	8.00	0.52	11.59	0.68

3.3 1000 pod mass of groundnut pods

The mean 1000 pod mass of groundnut pods of variety 1, 2 and 3 were 1270.66, 1266.88 and 1334.14 g respectively (Table 4). It is clear from table that the mass of groundnut pod increased with the increase in size of pods. Based on these values the feeding chute was designed so that it can occupy the maximum pod mass of 1334.14 g. It helped in designing the feeding chute. These values were in confirmation with study of Manjunatha et al 2017. The 1000 pod mass of groundnut pods of variety 1, 2 and 3 are given in Appendix-A.3.

Table 4: Mean values 1000 pod mass of groundnut

Parameter	Number of samples	Weight of 1000 pod mass of different varieties of groundnut pods, g		
		Varieties		
		1	2	3

		Mean	S.D.	Mean	S.D.	Mean	S.D.
1000 pods mass	5	1270.66	23.89	1266.88	23.29	1334.14	20.61

3.4 Bulk density of groundnuts pods

The mean bulk density of groundnut pods of variety 1, 2 and 3 were 0.36, 0.35 and 0.26 g/cm^3, respectively (Table 5). These values helped in designing the feeding chute to decide the bulk of pods that can accommodate in feeding chute. As the size of pod increased the bulk density decreased. Therefore, highest value of bulk density was considered with aim to accommodate the variety of size of groundnut pods. It also helped in designing the feeding chute volume. The bulk density of groundnut pods of variety 1, 2 and 3 are given in Appendix-A.4.

3.5 Angle of repose of groundnut pods

The mean angle of repose of groundnut pods of variety 1, 2 and 3 were 26.59°, 26.54° and 24.22° g/cm^3, respectively (Table 6). As the pod size increases, the angle of repose of groundnut pods also decreased. The angle of inclination of feeding chute selected for variety 1 and 2 was 27° while for variety 3 was 25°angle. These values helped in deciding the angle of inclination of feeding chute. Hence, higher value of angle repose was considered. The similar values were reported by Maduako and Hamman (2004). The angle of repose of groundnut pods of variety 1, 2 and 3 are given in Appendix-A.5.

Table 5: Mean values of bulk density of groundnut pods

Parameter	Number of samples	Bulk density of different varieties of groundnut pods, g/cm^3

		Varieties					
		1		2		3	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Bulk density	5	0.36	0.03	0.35	0.01	0.26	0.02

Table 6: Mean values of angle of repose of groundnut pods

Parameter	Number of samples	Angle of repose of different varieties of groundnut pods, degrees					
		Varieties					
		1		2		3	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Angle of repose	5	26.59	1.27	26.54	1.63	24.22	0.64

3.6 Moisture content of groundnut pods

The mean moisture content values of groundnut pods of variety 1, 2 and 3 were 5.37, 4.52 and 4.5 % respectively (Table 7). The moisture content of pods affects the decorticating efficiency of the decorticator. The high moisture content tends to increase the power consumption so it is necessary to dry the pods if moisture content is high before decortication. The values obtained were similar to Muhammad et al 2015.The moisture content of groundnut pods of variety 1, 2 and 3 are given in Appendix-A.6.

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3.7 Rupture force of groundnut pods

The mean rupture force values for groundnut pods of variety 1, 2 and 3 were 237.61, 231.01 and 337.86 N, respectively (Table 8**)**. It helps in designing the force needed by the four-bar linkage of crank that operated the decorticator shoe to decorticate the groundnut pods through its lever. It helps in designing the force needed by the four-bar linkage of decorticator to just rupture the groundnut pods through decorticating lever. The similar values were obtained by Muhammad et al 2015. The rupture force of groundnut pods of variety 1, 2 and 3 were given in Appendix-A.7.

Table 7: Mean moisture content values of groundnut pods

Parameter	Number of samples	Moisture content (w.b.) of different varieties of groundnut pods, %					
		Varieties					
		1		2		3	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Moisture content	5	5.37	0.4	4.52	0.17	4.5	0.19

Table 8: Mean rupture force of groundnut pods

Parameter	Number of samples	Rupture force of different varieties of groundnut pods, N		
		Varieties		
		1	2	3

		Mean	S.D.	Mean	S.D.	Mean	S.D.
Rupture force	5	237.61	25.36	231.01	24.71	337.86	44.13

4. CONCLUSION

The purpose of this study was to determine the different physical properties values of groundnut pods and kernels in order to select the average value among each physical property for each variety of selected groundnut pods for the development of battery-operated groundnut decorticator. The physical properties such as size of groundnut pods and kernels, 1000 pod mass, bulk density of pods, angle of repose, moisture content and rupture force were determined. It was observed that among the three varieties, the length of pod was found to have an average value of 30.84 mm for variety 1, 28.02 mm for variety 2 and 36.8 mm for variety 3. The width was found to have an average value of 12.01, 12.59 and 14.33 mm for variety 1, 2 and 3 respectively. The average value of thickness was found to have 10.79 mm for variety 1, 10.91 mm for variety 2 and 14.31 mm for variety 3. The length of kernels was found to have average values of 16.68 mm for variety 1, 19.28 mm for variety 2 and 18.7 mm for variety 3. The width of kernels was found to have average values of 11.59 mm for variety 1, 9.08 mm for variety 2 and 8 mm for variety 3. The 1000 pod mass were found to have an average values of 1270.66 g for variety 1, 1266.88g for variety 2 and 1334.14 g for variety 3. The bulk densities were found to have an average value of 0.36 g/cm^3 for variety 1, 0.35 g/cm^3 for variety 2 and 0.26 g/cm^3 for variety 3 of groundnut pods. The average angle of repose values for variety 1, 2 and 3 was 26.59° and 26.54° and 24.22°. The average values of moisture content were found to have 5.37, 4.52 and 4.5% for variety 1, 2 and 3 was respectively. The average values of rupture force for variety 1 was 237.61N, variety 2 was 231.01 N and for variety 3 was 337.86N.

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Appendix-A

Table A.1 Length, width and thickness of variety 1, variety 2 and variety 3 groundnut pods

Sample	Variety 1			Variety 2			Variety 3		
	L(mm)	W(mm)	T(mm)	L(mm)	W(mm)	T(mm)	L(mm)	W(mm)	T(mm)
1	38.7	14.71	14.40	33.76	12.51	10.30	31.58	13.65	9.49
2	37.8	14.63	15.01	35.12	11.60	11.06	36.06	13.24	10.96
3	39.9	14.06	14.20	34.73	13.36	10.58	34.79	13.18	11.34
4	39.3	14.34	14.01	35.45	11.86	11.34	36.42	12.64	11.25
5	39.6	14.20	13.16	37.34	12.40	10.96	36.94	12.77	10.87
6	35.2	14.60	14.49	27.65	11.75	10.01	28.60	12.72	10.68
7	32.7	14.09	14.30	27.09	12.33	11.06	26.18	12.54	10.96
8	36.1	13.65	14.68	27.83	13.16	12.30	29.24	13.75	12.39
9	35.7	14.76	13.44	29.94	12.95	11.82	29.13	13.53	12.30
10	35.2	14.07	14.59	26.18	11.91	11.25	26.18	13.19	11.15
11	35.5	14.15	14.63	28.89	11.51	9.82	19.07	13.06	9.91
12	32.7	14.59	14.20	31.25	11.75	10.87	18.76	12.54	10.30
13	36.1	14.33	14.36	28.35	10.65	10.01	18.97	12.27	10.44
14	34.7	14.76	14.11	28.06	11.34	9.58	20.12	12.21	10.43
15	35.2	14.62	14.30	33.13	10.49	10.18	17.45	12.14	10.28
16	41.3	14.14	14.91	25.46	12.38	11.06	24.64	12.93	11.13
17	38.0	14.14	14.11	30.40	12.00	10.43	29.27	13.54	11.01
18	37.0	14.18	15.33	32.06	12.34	11.29	32.25	13.14	11.13
19	38.1	14.19	13.90	32.00	11.63	11.18	32.50	13.17	11.37
20	37.5	14.35	14.08	32.03	12.25	10.71	32.22	12.79	10.75
Mean	**36.8**	**14.33**	**14.31**	**30.84**	**12.01**	**10.79**	**28.02**	**12.95**	**10.91**
SD	**3.1**	**0.67**	**0.65**	**3.74**	**0.91**	**0.85**	**6.62**	**0.80**	**0.92**

Table A.2 Length and width of variety 1, variety 2 and variety3 groundnut kernels

Sample	Variety 1		Variety 2		Variety 3	
	L(mm)	W(mm)	L(mm)	W(mm)	L(mm)	W(mm)
1	4.81	11.75	14.81	9.19	19.57	7.80
2	19.42	11.51	19.53	9.23	19.25	7.96
3	18.61	11.84	17.78	8.90	19.53	8.06
4	18.94	12.20	14.64	9.28	18.11	8.01
5	16.99	11.74	17.02	9.47	15.92	7.86
6	19.66	11.32	20.61	9.02	18.07	8.05
7	20.57	11.61	14.55	8.44	20.59	7.95
8	18.33	11.68	17.09	9.14	18.93	7.96
9	17.64	11.06	15.24	8.52	18.87	7.90
10	17.80	12.33	15.50	9.24	19.43	8.41
11	20.52	10.92	19.41	9.41	22.10	7.89
12	19.53	11.64	17.67	9.08	22.77	7.81
13	19.06	11.88	16.35	9.16	21.83	7.87
14	18.58	11.56	16.37	8.84	22.17	8.19
15	16.18	11.72	17.41	8.68	16.08	8.53
16	18.53	11.41	13.58	9.10	17.08	7.57
17	17.66	10.81	15.22	9.14	18.72	7.63
18	18.83	11.66	18.91	9.12	18.84	8.50
19	18.06	11.70	17.15	9.10	19.02	8.07
20	19.03	11.54	14.82	9.51	18.68	7.99
Mean	**18.70**	**11.59**	**16.68**	**9.08**	**19.28**	**8.00**
SD	**1.60**	**0.68**	**1.95**	**0.48**	**1.92**	**0.52**

Table A.3 1000 pod mass of variety 1, variety 2 and variety 3 of groundnut pods

Sample	1000 pod mass(g)		
	Variety 1	**Variety 2**	**Variety 3**
1	1326.82	1256.63	1257.58
2	1344.74	1250.45	1257.23
3	1364.57	1296.47	1294.17
4	1321.67	1254.79	1273.39
5	1312.90	1281.53	1252.01
Mean	**1334.14**	**1270.66**	**1266.88**
SD	**20.61**	**23.89**	**23.29**

Table A.4 Bulk density of variety 1, variety 2 and variety 3 of groundnut pods

Sample	Bulk density(g/cm^3)		
	Variety 1	**Variety 2**	**Variety 3**
1	0.35	0.32	0.37
2	0.37	0.40	0.35
3	0.35	0.38	0.31
4	0.36	0.38	0.35
5	0.37	0.40	0.39
Mean	**0.36**	**0.38**	**0.35**
SD	**0.01**	**0.04**	**0.03**

Table A.5 Angle of repose of variety 1, variety 2 and variety 3 of groundnut pods

Sample	Angle of repose(°)		
	Variety 1	**Variety 2**	**Variety 3**
1	25.10	23.72	24.92
2	26.67	24.21	24.86
3	28.61	24.87	24.49
4	27.03	24.31	24.24
5	25.27	24.00	24.59
Mean	**26.54**	**24.22**	**24.62**
SD	**1.63**	**0.64**	**0.67**

Table A.6 Moisture content of variety 1, variety 2 and variety 3 of groundnut pods

Sample	Moisture content(%)		
	Variety 1	**Variety 2**	**Variety 3**
1	4.33	5.65	4.71
2	4.59	5.43	4.40
3	4.58	5.02	4.47
Mean	**4.50**	**5.37**	**4.52**
SD	**0.19**	**0.40**	**0.17**

Table A.7: Rupture force of variety 1, variety 2 and variety 3 of groundnut pods

Sample	Rupture force(N)		
	Variety 1	**Variety 2**	**Variety 3**
1	326.39	222.26	253.42
2	409.93	238.80	229.46
3	340.71	195.83	262.28
4	291.27	265.57	199.15
5	320.99	232.59	243.73
Mean	**337.86**	**231.01**	**237.61**
SD	**44.13**	**25.36**	**24.71**