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INVESTIGATION OF ENGINEERING PROPERTIES OF GROUNDNUT PODS FOR ADVANCED PNEUMATIC POD COLLECTION SYSTEMS

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ABSTRACT

The determination of engineering properties of groundnut pods is crucial for designing various components of the groundnut pod collector (GPC), such as the centrifugal fan, cyclone separator, sieve and storage unit. Popular groundnut crop varieties were collected from the Main Oil Seed Research Station, Junagadh Agricultural University, Junagadh. These varieties are prominently cultivated by farmers in Gujarat. To assess the effectiveness and efficiency of the pneumatic GPC, distinct engineering properties of groundnut pods, such as terminal velocity (8.03 to 16.77 m/s), coefficient of friction (0.47 to 0.55), angle of repose (24° to 31°), and bulk density (0.22 to 0.29 g/cm³), along with moisture content ranging from 6.77% to 14.50%, were analyzed. Furthermore, the size-related properties of groundnut pods, especially for the oscillating sieving mechanism, were determined. The findings revealed that the average pod length, width, thickness, geometric mean, and sphericity varied from 14.95 to 45.56 mm, 11.12 to 20.03 mm, 10.58 to 19.23 mm, 12.01 to 24.97 mm, and 0.48 to 0.87, respectively, for all the varieties. The prime thrust of this research work was to establish the relationship between the above parameters and to explore the necessary references for achieving the desired results in the successful development and operation of the pneumatic GPC.

Key words : Groundnut production, high-oil content, growth pattern, lateral branches.

Introduction

Groundnut is valued for its high-oil content and edible seeds. It is the fourth most important source of edible oil and third most important source of vegetable protein in the world. Groundnut kernels contains about 63% carbohydrate, 19% protein and 6.5% oil (Lakhani and Vagadia, 2023). Gujarat is the largest producer contributing 42% of the total production of Groundnut followed by Rajasthan (17%) and Tamil Nadu (11%) (Anonymous, 2023).

In Gujarat, groundnut crop is cultivated across an area of 1.98 million hectares, resulting in a production of 4.49 million tonnes and an average productivity of 2259 kg per hectare. The primary districts for groundnut cultivation in Gujarat include Junagadh, Amreli, Rajkot, Bhavnagar, Jamnagar and Sabarkantha *etc*. Saurashtra is the heart of the Gujarat and India for groundnut production (Anonymous, 2023).

The varieties of groundnut fall into three groups in respect of the habit of growth, namely bunch (Spanish), semi-spreading and spreading. Spreading and semi-spreading types: These are varieties of groundnut belonging to the subspecies ‘hypogaea.’ Spreading types have lateral branches that remain close to the ground, creating a spreading appearance. Semi-spreading types share similar characteristics but may exhibit variations in growth pattern and branch development. Spanish Bunch Types: Spanish bunch types belong to the subspecies ‘fastigiata.’ They are erect varieties with floral axes found on the main axis and they have a continuous run of multifloral axes along lateral branches. Spanish bunch types are more branched, giving the mature plant a tightly bunched and bushy appearance. They are known for their upright growth and non-dormant seeds, maturing in 3 to 4 months (Rathnakumar *et al*., 2013).

In Gujarat, the spreading, semi-spreading and bunch types groundnut varieties are grown. The spreading varieties like GAUG-10, GG-11, GG-12,GG-13 *etc*., GG-20 semi spreading while bunch type varieties of groundnut like GG-2, GG-4, GG-7 *etc*. have been recommended and adopted by the farmers for cultivation in Saurashtra region. The groundnut is sown at the row spacing of 45 cm and 60 cm for bunch type and spreading type, respectively (Shukla, 2018). From the varieties realized by main oilseed research station (Anonymous, 2022), eighteen varieties were used for determine engineering properties of groundnut pods. The main focus of this research was to establish the relationship between the engineering parameters and to explore the required references for achieving the desired results in the successful development and operation of the pneumatic Groundnut Pod Collector (GPC).

Materials and Methods

The determination of physical and engineering property of groundnut pod is important for the designing of different components of the machine like fan, cyclone separator, sieve and storage unit etc. The popular eighteen varieties of groundnut (GG-39, GJG-31, GG-7, GG-23, GAUG-10, SB-XI, GG-38, GG-6, GG-4, GJG-JPS-1, GG-2, GG-3, GG-HPH-2, GG-41, GG-14, GG-40, GG-33 and GG-5 shown in Fig. 1) were collected from Main Oil Seed Research Station, Junagadh Agricultural University, Junagadh. These varieties are prominently cultivated by farmers of Gujarat. The selected varieties were used to determine the engineering properties.

Size

Twenty pods of the groundnut were selected for measurement to determine the size of groundnut pods in terms of length (L), width (W) and thickness (T). Using a Digital Vernier Caliper (Fig. 2) with a least count of 0.1 mm, dimensions L, W and T were measured along three major axes. The measurement considered the longest dimension in the longitudinal direction as length, the dorsoventral dimension as width, and the lateral dimension on the third axis as the thickness of the seed. To calculate the size of each pod in terms of geometric mean diameter (D_g), the following formula was used by Muhammad (2017).

$$Dg = (LWT)^{\frac{1}{3}} \tag{1}$$

Fig. 1 : Different groundnut verities.

Sphericity

Sphericity was defined as the ratio of the surface area of the sphere having the same volume as that of the grain to the surface area of the grain and it was used by Muhammad (2017).

$$\phi = \frac{(LWT)^{\frac{1}{3}}}{L} \tag{2}$$

Where,

L = Length of pod, mm;

W = Width of pod, mm; and

T = Thickness of pod, mm.

Determination of Bulk Density

The bulk density was determined by filling a known volume square box (1000cm^3) with the groundnuts up to its brim from a height of about 150 mm and the excess was removed by striking off the top with stick and weighing the contents of square box shown in Fig. 3. The bulk density (ρ_b) of groundnut pods was then calculated by dividing the mass (*M*) to the volume (V_b) of 1000 cm^3 (Aydin, 2007).

$$\rho_b = \frac{M}{Vb} \tag{3}$$

Fig. 2 : Digital Vernier caliper.

Fig. 3 : Determination of Bulk Density.

Fig. 4 : Oven-drying method for determination of moisture content.

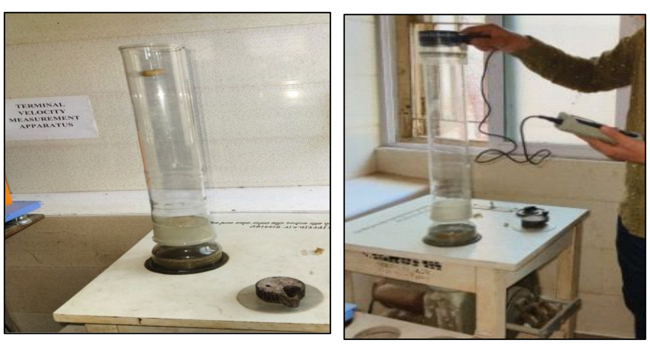

Fig. 5 : Measurement of terminal velocity.

Angle of repose

The angle of repose was determined using the method explained by Waziri and Mittal (1983). The apparatus used for measuring the angle of repose of pods involved filling pods into a box with a circular platform, surrounded by a metal funnel leading to a discharge hole. Three replicated trials were conducted. The pods were allowed to escape from the box, leaving a free-standing cone of pods on the platform. The height (h) of the cone and the diameter (D) of the platform were measured using a traveling microscope. The angle of repose was then calculated using the following formula:

$$\theta = \tan^{-1}\left(\frac{2h}{D}\right) \tag{4}$$

Where,

θ = angle of repose (degree)

h = H_a-H_b

D = Diameter of circular platform

Moisture content

The moisture content of pods was determined by taking five samples of each from five random places in the field and testing them for moisture content using the Oven-drying method (Fig. 4) specified in IS. 7897-1997 (Anonymous, 1997). The samples of pods were placed in an air-oven maintained at 100+2°C and dried for at least 2 hours. They were then cooled in desiccators and weighed. The process of heating, cooling and weighing was repeated until the difference between two successive weighing was less than one milligram. The moisture content was calculated using the formula:

$$MC_{(wb)} = \frac{W_1 - W_2}{W_1 - W} \times 100 \tag{5}$$

Where,

W_1= Mass in g of the dish with the material before drying

W_2= Mass in g of the dish with the dried material and

W = Mass in g of the empty dish

Terminal velocity

The terminal velocity, necessary for deciding the suction velocity of a centrifugal fan for groundnut pod collection, is defined as the velocity of air at which the grain neither blows upward nor falls downward, remaining in a suspended state. Terminal velocities of groundnut pods and foreign materials were determined using an air column device (Fig. 5). For each experiment, a specimen was placed into an air stream from the top of the air column. The airflow rate was steadily increased until the seed became suspended in the air stream. A digital anemometer measured the air velocity that kept the seed in suspension. Each sample consisted of 10 pods randomly selected at the same moisture content. Three replications were taken for each sample (Gupta *et al*, 1997 and Bitra, 2013).

Coefficient of friction

The coefficient of friction of groundnut pods and kernels was determined using the method described by (Dutta *et al*., 1988). The groundnut pods and kernels

Fig. 6 : Tilting table apparatus for measurement of coefficient of friction.

were taken into a box of 75 mm length, 75 mm with and 75 mm height without base and placed on an adjustable inclined plate. The adjustable inclined plate was raised slightly until the sample box starts to slide on the inclined plate and the inclined plate at which the sample box just begins to slide tight with the protractor through the adjustable screw as shown in Fig. 6.

The vertical distance (P) and horizontal distance (Q) were measured by the scale, and the coefficient of friction of groundnut pods and kernels was determined by the following equation (3.5). The angle of internal friction can be measured directly by the protractor at which the sample box just starts slide on the inclined plate.

$$\mu = \tan Ø = \frac{Y}{X} \quad (6)$$

$$Ø = \tan^{-1}\left(\frac{Y}{X}\right) \quad (7)$$

Where,

Y = vertical distance from the fixed plate to the adjustable plate while sample box just start slide;

X = horizontal distance between the connection point of plates to the point when sample box just start slide, and

Ø = angle between the inclined plate and horizontal plate at which the sample box just start slide (angle of internal friction).

Results and Discussion

The engineering properties of groundnut varieties were measured after digging and sun-drying for 5 to 7 days, this process ensured that the groundnuts were sufficiently dried and stable for accurate measurement

Table 1 : Engineering properties of groundnut pods.

Variety	Length (mm)	Width (mm)	Thickness (mm)	Geometric mean diameter	Sphericity
GG-39	27.54±8.52	15.02±0.71	16.45±0.27	18.83±2.04	0.66±0.12
GJG-31	23.36±5.26	12.3±0.26	13.44±1.18	15.21±1.57	0.68±0.09
GG-7	23.80±7.36	13.05±0.62	14.04±0.59	16.2±1.6	0.67±0.15
GG-23	28.68±6.76	13.43±0.41	14.98±0.77	17.71±1.24	0.61±0.11
GAUG-10	27.71±10.31	12.62±0.37	14.04±1.35	16.98±2.68	0.59±0.13
SB - XI	21.57±6.09	11.4±1.46	12.14±1.53	14.29±2.28	0.65±0.11
GG-38	25.77±8.04	12.18±0.93	12.61±0.85	15.7±1.84	0.6±0.12
GG-6	22.55±6.78	11.91±1.12	12.48±1.06	14.9±2.06	0.64±0.11
GG-4	23.64±4.81	11.69±0.67	12.83±0.74	15.1±1.53	0.62±0.06
GJG-HPS-1	28.12±8.22	12.97±0.21	14.77±1.19	17.39±2.01	0.60±0.11
GG-2	22.98±8.48	11.79±0.54	12.48±0.87	14.94±1.55	0.64±0.18
GG-3	21.94±7.95	12.1±1.47	13.38±1.38	15.25±2.82	0.67±0.12
GG-HPH-2	35.15±11.88	17.65±1.07	18.81±1.22	21.82±3.18	0.67±0.13
GJG-41	25.47±7.32	13.76±1.53	14.95±1.89	17.27±2.75	0.66±0.09
GG-14	25.23±7.97	12.36±0.28	13.08±0.56	15.77±2.1	0.63±0.15
GG-40	25.48±8.22	13.05±0.48	14.13±1.66	16.68±2.48	0.63±0.11
GG-33	25.3±7.54	12.78±0.76	13.61±0.53	16.28±2.07	0.63±0.11
GG-41	25.31±6.56	13.26±0.52	14.08±0.95	16.62±1.7	0.64±0.11
GG-5	24.77±7.55	13.03±0.76	13.63±0.98	15.99±1.94	0.67±0.17
Mean	**27.36**	**14.31**	**13.21**	**16.79**	**0.65**
Range	**14.95-45.56**	**11.12-20.03**	**10.58-19.23**	**12.01-24.97**	**0.48-0.87**
SD	**7.22**	**1.85**	**1.59**	**2.63**	**0.10**
CV	**26.40**	**12.95**	**12.01**	**15.64**	**15.75**

Table 2 : Engineering Properties of groundnut pods.

Variety	Moisture content (%)	Terminal velocity (m/s)	Coefficient of friction	Angle of repose (°)	Bulk Density (g/cm³)
GG-39	8.37	10.85±0.21	0.55	25	0.29±0.015
GJG-31	7.00	13.54±1.59	0.49	30	0.22±0.01
GG-7	8.43	13.05±0.69	0.49	29	0.23±0.02
GG-23	7.86	13.66±0.47	0.51	28	0.23±0.01
GAUG-10	7.98	12.99±0.9	0.51	29	0.24±0.01
SB- X I	10.70	13.05±0.58	0.47	31	0.23±0.01
GG-38	8.53	13.66±0.77	0.49	30	0.23±0.01
GG-6	6.77	14±2.47	0.49	30	0.23±0.01
GG-4	8.51	12.96±1.08	0.49	30	0.24±0.01
GJGJPS-1	7.68	13.87±0.53	0.55	28	0.22±0.01
GG-2	8.62	12.77±0.4	0.47	31	0.23±0.01
GG-3	9.21	14.35±2.11	0.47	29	0.22±0.01
GJHPH-2	14.50	12.77±1.14	0.55	24	0.24±0.01
GJG-41	8.24	13.74±0.24	0.49	28	0.23±0.01
GG-14	8.97	13.63±0.76	0.49	29	0.23±0.01
GG-40	11.10	12.8±0.17	0.49	29	0.25±0.01
GG-33	8.65	11.06±2.62	0.49	29	0.26±0.01
GG-41	7.84	14.13±0.94	0.49	28	0.23±0.01
GG-5	8.74	13.11±0.7	0.49	29	0.23±0.01
Mean	**8.83**	**13.27**	**0.50**	**28.74**	**0.24**
Range	**6.77-14.5**	**8.03-16.77**	**0.47-0.55**	**24-31**	**0.22-0.29**
SD	**6.77**	**8.03**	**0.47**	**24.00**	**0.22**
CV	**1.72**	**1.35**	**0.03**	**1.76**	**0.02**

of their physical characteristics. The recorded engineering properties of groundnut varieties, as detailed in Tables 1 and 2, show considerable variability along with the minimum, maximum and standard deviation values.

Using the detailed data from Table 1 and 2 on various groundnut varieties and their engineering properties integrated these measurements to understand how they influenced the development and functionality of a pneumatic groundnut pod collector for collecting lost pods from the field. The development of a pneumatic groundnut pod collector is influenced by several key properties of groundnut pods, as identified in the study. The angle of repose, ranging from 24° to 31° across different varieties, indicates the ease of pod flow. Varieties with lower angles, such as GGHPS-2 and GG-39 at 25°, suggest better flow ability, reducing the need for mechanical agitators and ensuring smooth pod flow into the system. Similarly, Maduako and Hamman (2004) identified analogous results.

Terminal velocities, ranging from approximately 11.06 m/s to 14.35 m/s, directly impact the design of the pneumatic conveying system. Higher terminal velocities, like GG-6 and GG-3, require higher air speeds for lifting and transporting pods, influencing the design of the centrifugal fan to ensure sufficient airflow without excessive energy consumption. A suitable terminal velocity range of approximately 15 to 16 m/s was identified for efficient pneumatic conveyance of groundnut pods, minimizing the conveyance of other materials. This finding is consistent with the results reported by Salman *et al*. (2011) and Qin *et al*. (2023).

Coefficients of friction, generally between 0.47 and 0.55, affect how pods move against surfaces of the collector and the conveyance system. Varieties with higher coefficients of friction, such as GGHPS-2, GG-39 and GJHPH-2 at 0.55, may require surfaces with reduced friction to prevent pod damage and facilitate easier movement . Likewise, Choudhary *et al*. (2020) reported similar results.

Bulk densities ranging from about 0.22 g/cm³ to 0.29 g/cm³ are crucial for cyclone separator design and cleaning mechanism development. Lower bulk densities, like GJG-31 and GJGJPS-1 at 0.22 g/cm³, make pods easier to separate from heavier soil particles but may also make them more susceptible to being carried away with lighter debris. Careful calibration of air flow and separator geometry is necessary for efficient separation. Similarly, Bitra (2013) identified analogous results.

These properties play a critical role in the design and optimization of pneumatic groundnut pod collection systems, ensuring efficient and effective harvesting while minimizing energy consumption and damage to the pods.

Conclusion

Groundnut varieties exhibited different engineering properties after sun-drying for 5 to 7 days of harvesting. GJHPH-2 had the longest length (35.15 mm) and widest width (17.65 mm), while SB-XI showed the shortest length (21.57 mm) and narrowest width (11.40 mm). Additionally, GJHPH-2 had the thickest pods (18.81 mm) and the largest geometric mean diameter (21.82 mm), while SB-XI had the smallest geometric mean diameter (14.29 mm). Sphericity ranged from 0.59 (GAUG-10) to 0.68 (GJG-31). Groundnut varieties vary in moisture content (6.19% to 14.50%), terminal velocities (10.85 m/s to 14.35 m/s), coefficients of friction (0.47 to 0.55), angles of repose (24° to 31°) and bulk densities (0.22 g/cm³ to 0.29 g/cm³). These properties are crucial for designing efficient pneumatic groundnut pod collector and ensuring optimal conveyance, while minimizing energy consumption and damage to the pods.

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References

Anonymous (1997). *Test code for chaff cutter*. IS: 7897–1997. Bureau of Indian Standards, New Delhi, India.

Anonymous (2022). *Main Oilseeds Research Station*, Junagadh Agricultural University, Junagadh. http://www.jau.in/index.php/resources/research-stations-top/south- saurashtra/main-oilseeds-research-station-groundnut-junagadh(Accessed on 10th May, 2023).

Anonymous (2023). Directorate of Agriculture, Govt. of Gujarat. District-wise Area, Production and Yield of Important Food & Non-food Crops in Gujarat State.

Anonymous (2023). United States Department of Agriculture Peanut Explorer. Available at https://ipad.fas.usda.gov/cropexplorer/cropview/commodityView.aspx?cropid=2221000 Accessed on 25th December, 2023.

Aydin, C. (2007). Some engineering properties of peanut and kernel. *J. Food Engg.*, **79(3)**, 810–816.

Bitra, V.S.P. (2013). Physico-mechanical, aerodynamic, thermodynamic and thermal properties of peanut pods, kernels and shells. *In*: Exposito, I.L. and Blazquez, A.B. (ed), Peanuts: Bioactivities and Allergies, pp. 21-76. Nova Science Publishers Inc., New York.

Choudhary, V., Machavaram R., Vikas and Singh R.S. (2020). engineering properties of groundnut pods and kernels: a key role for designing the post-harvest processing equipment. *Int. J. Curr. Microbiol. Appl. Sci.*, **9(8)**, 1751-1761.

Dutta, S.K., Nema V.K. and Bhardwaj R.K. (1988). Physical properties of grains. *J. Agricult. Engg. Res.*, **39**, 259–268.

Gupta, R.K. and Das S.K. (1997). Physical properties of Sunflower seeds. *J. Agricult. Engg Res.*, **66(1)**, 1–8.

Lakhani, A.L. and Vagadia V.R. (2023). Development and performance evaluation of shelling unit of power operated groundnut decorticator. *Int. J. Agricult. Sci.*, **19(1)**, 254-260.

Muhammad, A.I., Ahmad R.K. and Lawan I. (2017). Effect of moisture content on some engineering properties of groundnut pods and kernels. *Agricult. Engg. Int.: CIGR J.*, **19(4)**, 200–208.

Qin, M., Jin Y., Luo W., Wu F., Shi L., Gu F., Cao M. and Hu Z. (2023). Measurement and CFD-DEM Simulation of Suspension Velocity of Peanut and Clay-Heavy Soil at Harvest Time. *Agronomy*, **13**, 1735.

Rathnakumar, A.L., Singh R., Parmar D.L. and Misra J.B. (2013). Groundnut*: a crop profile and compendium of notified varieties of India*: Tech Bull, 1st edn., pp. 1-118. Directorate of Groundnut Research, Junagadh, Gujarat, India.

Salman, A. Kh., Al-Rajhi M.A.E., El-Rayes A.I. and Abd El-Mottaleb A.F. (2011). The effect of moisture content on some physical and aerodynamic properties of peanut and its residues. *J. Soil Sci. Agricult. Engg.*, **2(12)**, 1243-1253.

Shukla, S. (2018). Design development and performance evaluation of groundnut pod collector. *Ph.D. Thesis* (*Unpublished*). Junagadh Agricultural University, Junagadh.

Waziri, A.N. and Mittal J.P. (1983). Design related physical properties of selected agricultural products. *Agricultural Mechanization in Asia, Africa and Latin America*, **14(1)**, 59-62.