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Studies the physical properties of castor (*Ricinus communis* L.) seeds

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Abstract

Agricultural equipment manufacturers and engineers must consider seed properties when designing and developing machinery and equipment for planting, harvesting, processing, packaging, and storing seeds. A seed metering unit is developed based on several properties such as size, geometric mean diameter, thousand seed weight, volume, surface area, sphericity, bulk density, true density, porosity and angle of repose. Initially, seeds' physical properties were calculated. There are two varieties of castor seed available, GCH-7 and GCH-8. As a result, the seeds initially contained 6.24% and 5.98% dry matter of GCH-7 and GCH-8, respectively. As a result, the mean length, width, thickness, arithmetic mean diameter, geometric mean diameter, volume, surface area, sphericity, bulk density, true density, porosity, angle of repose, and thousand seed weight for GCH-7 were 12.29, 8.51, 6.24, 9.01, 8.49 mm, 351.35 mm^3, 200.18 mm, 69.00%, 653.40, 1157.00 kg. m^{-3}, 43.46%, 29.00˚ and 343.00 g, respectively and for GCH-8 were 12.40, 8.92, 6.30, 9.21, 8.67 mm, 376.81 mm^3, 209.34 mm, 70.03%, 671.00, 1198.00 kg. m^{-3}, 44.01%, 29.23˚ and 372.00 g, respectively. We developed efficient planter components based on these properties.

Keywords: Castor seed, moisture content, physical properties and metering unit

Introduction

In tropical climates, subtropical climates, and temperate climates, you can grow castor (*Ricinus communis* L.), which belongs to the Euphorbiaceae family. The castor crop is one of the oldest crops still being cultivated; however, it contributes only 0.15 percent to global vegetable oil production. Since this crop produces the only commercial source of hydroxylate fatty acids, it is considered to be of importance to the global specialty chemical industry. Dry and semi-arid regions are ideal environments for growing the castor plant. In 2020-21, World major producing countries are India (16.51 LT), Mozambique (0.72 LT), China (0.17 LT), Thailand (0.12 LT) and Myanmar (0.12 LT) (www. pjtsau.edu.in). As of the year of report, Gujarat state outshined all other states in terms of castor contribution in India, with 80.98 per cent of area and 83.53 per cent of production. For the year 2020-21, Gujarat's total area under castor is estimated to be 6.53 lakh hectares with 13.45 lakh tons of production and 2060.26 kg. ha^{-1} yield. The majority of castor production in Gujarat comes from five districts: Banaskantha (2.64 LT), Kutch (2.29 LT), Patan (1.90 LT), Mehsana (1.96 LT) and Surendranagar (1.00 LT). Oil content ranges from 46 to 51.8 percent, protein ranges from 17.1 to 24.4%, and crude fiber ranges from 18.2 to 26.5% (Yuldasheva *et al.*, 2002) [2]. The castor seed is an important oil crop known for its high levels of ricinoleic acid (C18H34O3), an unsaturated hydroxy fatty acid containing conjugated bonds. This oil has many positive properties due to its high ricinoleic acid concentration of over 85 percent (Alam *et al.*, 2010) [3].

Developing new equipment for processing and sowing the crop is difficult due to the lack of basic engineering properties of plant material (Safieddin *et al.*, 2012) [4]. Mechanical and physical properties provide important engineering information for the design of machines, storage structures, processing and quality control. It is important to make sure engineers understand these basic properties so they can exploit them to find new applications for the plant material (Mohsenin 1978 and Ayuga *et al.*, 2005) [5, 6]. As part of sowing operations, seeds are bear, put in rows at desired depths and spacings, covered with soil, and compacted properly (Soyoye *et al.*, 2016) [7]. This mechanized planting equipment must be designed with some consideration of the characteristics of the seed being planted before fabrication begins (Jouki and Khazaei, 2012) [8]. This issue can only be solved by developing a precise metering mechanism for sowing seed that allows for improved seed singulation and minimal seed loss in the field, and the evaluation of engineering properties of seeds is crucial.

An efficient planter relies on a seed metering mechanism. Design and performance parameters of a planter are affected by it. It is very important to consider the physical properties of the seed when designing a planter. In addition to planters, seeds' physical and mechanical properties also affect planters and processing machines such as cleaners, graders, sorters, threshers, and transporting components. The most important physical properties for designing seed metering and other seed planter components are size, shape, mass, angle of repose, coefficient of friction, bulk density, and aerodynamics. Seeds also affect the internal components of the planter based on their coefficient of friction when they are placed on different surfaces. In order to choose the frame for planter weight, size, shape, axial dimensions, roundness, and sphericity play an important role in determining the maximum size of the cell or cup in the seed plate. Bulk density and moisture content can help us understand how seeds interact with the material for the hopper of the planter, while angle of repose ensures seeds flow freely in the hopper (Jayan and Kumar, 2006) [10]. The physical properties of the seeds must therefore be tested before designing and fabricating the planter's components.

Nomenclature					
L	:	Length, mm	ϕ	:	Sphericity,%
W	:	Width, mm	ρ_b	:	Bulk density, kg m^{-3}
T	:	Thickness, mm	ρ_t	:	True density, kg m^{-3}
D_a	:	Arithmetic mean diameter, mm	ε	:	Porosity,%
D_g	:	Geometric mean diameter, mm	θ	:	Angle of repose, deg
W_{1000}	:	Thousand seed weight, g	AES	:	Agro Ecological Situation
V	:	Volume of seed, mm^3	GCH	:	Gujarat castor hybrid
S	:	Surface area of seed, mm^2	°	:	Degree

Methodology

Samples selection and preparation: This study was conducted at Sardarkrushinagar Dantiwada Agricultural University, Gujarat, India, in 2021. GCH-7 and GCH-8 castor seeds collections were used in this study. Figure 1 shows samples from the collections. Some of the castor bean varieties grown in Gujarat (India) North Gujarat Agro-climatic Zone IV (AES-I). They were obtained from the Oil Seeds Research Station of the S. D. Agricultural University. It was necessary to clean the collections thoroughly in order to ensure that there was no dirt, dust, stones, damaged or immature seeds, or other foreign materials present.

GCH-7	GCH-8

Fig 1: Castor seeds (*Ricinus communis* L.)

The initial moisture content of the seeds was determined by drying them in a hot air oven set at 105 ˚C for 24 hours. Results showed the seeds to have mean moisture levels of 6.24 and 5.98 percent by dry weight of GCH-7 and GCH-8, respectively. On the basis of preliminary studies and in accordance with ASAE standards S352.3 (ASAE, 1994) [11], the drying conditions were determined.

Laboratory measurements were made of the size, the sphericity, the thousand kernel weight, the geometric mean diameter, the surface area, the bulk density, and the angle of repose of the grains. The properties of these materials have been utilized in the development of planter components that work efficiently.

Dimensions and one thousand seeds weight

In order to determine average seed size, 100 seeds were randomly selected and measured using a digital vernier caliper with an accuracy of 0.01 mm along their three linear dimensions, length (L), width (W), and thickness (T). The weight of one thousand seeds (W_{1000}) was calculated by counting 100 seeds of castor seeds on an electronic counter machine, weighing them on an electronic scale with a 0.01 g accuracy, and extrapolating that weight to 1000 seeds. The arithmetic and geometric means of the three axial dimensions were used to calculate the average seed diameter. Based on the following relationships (Mohsenin, 1986) [9], we calculated the arithmetic mean diameter (D_a) and geometric mean diameter (D_g) of the seed.

$$D_a = \frac{L + W + T}{3} \quad \ldots (1)$$

$$D_g = (LWT)^{\frac{1}{3}} \quad \dots (2)$$

Sphericity, volume and surface area

The sphericity of a seed is defined as the ratio between its surface area and the surface area of a sphere of the same volume. In order to determine this value, we used the equation (Mohsenin, 1986) [9].

$$\phi = \frac{(LWT)^{\frac{1}{3}}}{L} \quad \dots (3)$$

Where: ϕ is the sphericity; L is the length in mm; W is the width in mm; and T is the thickness in mm.

Seed volume (V) and surface area (S) were calculated using the following equations (Jain and Bal, 1997) [12].

$$V = 0.25\left[\left(\frac{\pi}{6}\right)L(W+T)^2\right] \quad \dots (4)$$

$$S = \frac{\pi B L^2}{(2L-B)} \quad \dots (5)$$

Where,

$$B = \sqrt{WT}$$

True density, bulk density and porosity

To determine the bulk density (ρ_b) of castor seeds, seeds were poured from a constant height into an empty glass container of predetermined volume and weight, then struck off the top level and weighed. Mass to volume ratio was expressed as bulk density (Varnamkhasti *et al.*, 2008) [13]. To avoid compaction of the material in the container, care was taken during the experiment. Toluene displacement method (Mohsenin, 1986) [9] was used to determine the true density (ρ_t). Seeds absorb toluene (C7H8) less efficiently than water, so it was used. Aside from its low surface tension, it also has low dissolution power and fills even shallow dips in seeds (Kabas *et al.*, 2007 and Demır *et al.*, 2002) [14, 15]. Castor seeds were analysed based on bulk density and true density to determine their porosity at different moisture contents (Mirzaee *et al.*, 2009) [16].

$$\varepsilon = \frac{(\rho_t - \rho_b)}{\rho_t} \times 100 \quad \dots (6)$$

Where, ε is the porosity in%, ρ_b is the bulk density in kg.m^{-3} and ρ_t is the true density in kg.m^{-3}.

Angle of repose and coefficient of static friction

The angle of repose describes how piled materials stand in relation to the horizontal. In order to measure this, a plywood box of 140×160×35 mm and two plates were used. After the box was filled with seeds, the adjustable plate was gradually inclined so that the seeds would assume a natural slope. This was referred to as the emptying angle of repose (Gharibzahedi *et al.*, 2010 and Tabatabaeefar, 2003) [17, 18].

Statistical analysis: The data were analyzed using descriptive statistics such as mean, standard deviation, and coefficient of variation.

Results and Discussion

Size and Shape: GCH-7 and GCH-8 are two castor varieties. Table 1 shows their major, intermediate, and minor dimensions. As for GCH-7, the mean seed length ranged between 10.86 to 13.26 mm, the mean intermediate dimensions ranged between 7.84 to 9.07 mm, and the mean minor dimensions ranged between 5.77 to 6.63 mm, with mean values of 12.29, 8.51, and 6.24 mm, respectively. The length, width, and thickness of GCH-8 seeds range from 10.94 to 13.59 mm, 8.36 to 9.42 mm, and 5.80 to 6.63 mm, respectively. Both varieties have a geometric mean diameter of 8.49 and 8.67 mm. Specifically, GCH-7 has a sphericity of 0.69, while GCH-8 has a sphericity of 0.70. Based on these observations, the castor seed was oblong in shape.

Fig 2: Dimension measurement

Table 1: Biometric observation of the castor seeds

Seed Varieties	Value	Length,	Width,	Thickness,	Arithmetic mean diameter,	Geometric mean diameter,	Sphericity, %

		mm	mm	mm	mm	mm	
GCH-7	Minimum	10.86	7.84	5.77	8.18	7.76	67.00
	Maximum	13.26	9.07	6.63	9.58	9.00	71.00
	Mean	12.29	8.51	6.24	9.01	8.49	69.00
	SD	0.616	0.318	0.273	0.370	0.336	0.012
	CV	5.011	3.732	4.371	4.110	3.963	1.751
GCH-8	Minimum	10.94	8.36	5.80	8.37	7.93	66.80
	Maximum	13.59	9.42	6.63	9.87	9.24	72.46
	Mean	12.40	8.92	6.30	9.21	8.67	70.03
	SD	0.654	0.291	0.209	0.362	0.318	1.497
	CV	5.275	3.268	3.320	3.930	3.671	2.138

Thousand seed weight

Table 2 displays the test weights for both castor seed varieties. As a result of different castor seed sizes, both varieties had varying test weights. There is an average thousand grain weight of 343.00 g for GCH-7 and 372.00 g for GCH-8 castor seeds. Consequently, test weights vary very little. Using the thousand seed weight of castor seeds as a primary factor, the seed rate per hectare is estimated.

Bulk density and true density

Table 2 shows the bulk density of both varieties. It was found that the average bulk density of seeds from the GCH-7 and GCH-8 varieties was 653.40 kg m^{-3} and 671.00 kg m^{-3}, respectively. Variations in bulk density between varieties were caused by differences in grain weight and particle distribution, i.e., variation in size. GCH-7 and GCH-8 seeds had a mean true density of 1157 and 1198.43 kg m^{-3}, which ranged between 1090 - 1251 kg m^{-3} and 1188.00 - 1209.15 kg m^{-3}, with a coefficient of variation of true density of 3.98 and 0.64 percent, respectively.

Angle of repose

Castor seed varieties showed average angles of repose of 29.0 and 29.23 degrees, respectively. Castor seeds can be flowed freely if the seed hopper sidewalls are sloped according to the angle of repose.

Table 2: Gravimetric properties of the castor seeds

Seed Varieties	Value	Weight, g	Volume, mm^3	Bulk density, kg m^{-3}	True density, kg m^{-3}	Porosity,%	Surface area, mm	Angle of repose, °
GCH-7	Minimum	335.00	265.90	640.50	1090.00	40.97	167.58	27.50
	Maximum	355.50	416.26	663.50	1251.00	47.24	224.35	30.00
	Mean	343.00	351.35	653.40	1157.00	43.46	200.18	29.00
	SD	5.893	40.763	7.644	46.027	2.041	15.625	0.882
	CV	1.718	11.602	1.170	3.978	4.697	7.806	3.041
GCH-8	Minimum	365	286.99	664.50	1188.00	43.10	175.43	28.45
	Maximum	380	455.74	683.50	1209.15	44.42	236.73	30.15
	Mean	372.00	376.81	671.00	1198.43	44.01	209.34	29.23
	SD	5.416	41.243	7.945	7.694	0.525	14.985	0.621
	CV	1.456	10.945	1.184	0.642	1.193	7.158	2.125

Conclusion

According to the study on the physical properties of GCH-7 and GCH-8 castor seed varieties, the following conclusions were reached. In the metering plate, the shape and size of each cell will be determined mostly by the size and shape of the seeds. According to the results, the length, width, and thickness vary from 10.86 to 13.59, 7.84 to 9.42, and 5.77 to 6.63 mm, respectively. Considering that castor seeds have an oval shape, the metering plate cells should have an oval shape as well, so the seed can be easily held within them. In order for the sidewalls of the hopper to not be less than the angle of repose of the seeds, the angle of repose of the seeds should be up to 30.15 degree. Hopper designs are based on frictional properties.

References

1. https://pjtsau.edu.in/files/AgriMkt/2022/Ocotber/castor-Ocotber-2022.pdf
2. Yuldasheva NK, Ul'Chenko NT, Glushenkova AI. Lipids of *Ricinus communis* seeds. Chem Nat Compd. 2002;38(5):413-415.
3. Alam I, Sharmin SA, Mondal SC, Alam J, Khalekuzzaman M, Anisuzzaman M, *et al*. *'In vitro'* Micropropagation through Cotyledonary Node Culture of Castor Bean (*Ricinus communis* L.). Aust J Crop Sci. 2010;4(2):81-84.
4. Safieddin AM, Najafi G, Ghobadian B, Tavakkoli HT. Determination of some mechanical properties of castor seed (*Ricinus communis* L.) to design and fabricate an oil extraction machine. [Publication Status Unknown].
5. Mohsenin NN. Physical Properties of Plant and Animal Materials. New York: Gordon and Breach Science Publishers; c1978. p. 891.
6. Ayuga F, Aguado P, Gallego E, Ramirez A. New steps towards the knowledge of silos behaviour. Int Agrophys. 2005;19(1).
7. Soyoye BO, Ademosun OC, Olu-Ojo EO. Manually operated vertical seed-plate maize planter. CIGR J. 2016;18(4):70-80.
8. Jouki M, Khazaei N. Some physical properties of rice seed *(Oryza sativa*). Res J Appl Sci Eng Technol. 2012;4(13):1846-1849.
9. Mohsenin NN. Physical properties of plant and Animal Materials. 2nd revised and updated edition. New York: Gordon and Breach Science Publishers; c1986.
10. Jayan PR, Kumar VJF. Planter design in relation to the

physical properties of seeds. J Trop Agric. 2006;42:69-71.
11. ASAE. Moisture measurement-ungrounded grains and seeds. ASAE Standards 1994. St. Joseph, MI: ASAE; 1994. p. 469.
12. Jain RK, Bal S. Properties of pearl millet. J Agric Eng Res. 1997;66(2):85-91.
13. Varnamkhasti MG, Mobli H, Jafari A, Keyhani AR, Soltanabadi MH, Rafiee S, *et al*. Some physical properties of rough rice (*Oryza Sativa* L.) grain. J Cereal Sci. 2008;47(3):496-501.
14. Kabas O, Yilmaz E, Ozmerzi A, Akinci I. Some physical and nutritional properties of cowpea seed (*Vigna sinensis* L.). J Food Eng. 2007;79(4):1405-1409.
15. Demır F, Doğan H, Özcan M, Haciseferoğullari H. Nutritional and physical properties of hackberry (*Celtis australis* L.). J Food Eng. 2002;54(3):241-247.
16. Mirzaee E, Rafiee S, Keyhani A, Djom-eh ZE. Physical properties of apricot to characterize best post-harvesting options. Aust J Crop Sci. 2009;3(2):95-100.
17. Gharibzahedi SMT, Mousavi SM, Moayedi A, Garavand AT, Alizadeh SM. Moisture-dependent engineering properties of black cumin (*Nigella Sativa* L.) seed. Agric Eng Int: CIGR J. 2010;12(1):194-202.
18. Tabatabaeefar A. Moisture-dependent physical properties of wheat. Int Agrophys. 2003;17(4):207-211.