International Journal of Bio-resource and Stress Management 2016, 7(6):1279-1283 HTTPS://DOI.ORG/10.23910/IJBSM/2016.7.6.1693

Full Research Article

Studies on Physical Properties of Pelleted Onion (*Allium cepa* L.) Seeds

Anand Gautam*, Rohinish Khurana, Gursaheb Singh Manes and Anoop Kumar Dixit

Dept. of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana, Punjab (141 004), India

Article History

Manuscript No. AR1693
Received in 20th September, 2016
Received in revised form 29th November, 2016
Accepted in final form 6th December, 2016

Correspondence to

**E-mail*: anand-coaefpm@pau.edu

Keywords

Onion, pelleted seed, small seeds, test weight

Abstract

Onion (*Allium cepa* L.) is one of the major vegetable crops grown throughout India. Pelletizing of the onion seed by providing a seed coat helps in changing the physical characteristics of the seed. Experiment was conducted for studying the physical properties of pelleted onion seed and these were compared to un-pelleted seed. The onion seed of variety Punjab Naroya (PN) was used throughout the experiment. The physical properties namely size, shape, thousand grain weight, angle of repose, bulk density and coefficient of static friction are important from engineering view point. The seeds were got pelletized in three categories i.e. the seed to coating material was in the ratio of 1:1, 1:2 and 1:3. The geometric mean diameter was measured for the three categories are 2.45, 2.82, and 3.07 mm. In comparison, the geometric mean diameter for un-pelleted seed was 2.00 mm. The average values of angle of repose for the cultivars under study as observed in the laboratory was 29.50°, 24.78°, and 23.70° respectively for Pelleted 1:1, 1:2 and 1:3 onion seeds. In comparison, the average value of angle of repose for un-pelleted seed was 31.61°. The values of porosity are decreased in gradually un-pelleted to 1:1, 1:2 and 1:3 pelleted seeds whereas the porosity for 1:3 Pelleted seed was 41.84% and is the lowest amongst the other cultivars. The porosity of un-pelleted seed was the highest (53.3%).

1. Introduction

Onion (*Allium cepa* L.) is one of the major vegetable crops grown throughout India. It is widely grown in different parts of the country mainly by small and marginal farmers. India produces about 13% of total onion produced in the world and ranks second after China, with an annual production of 12.157 mt, from an area of 0.805 mha having productivity of 15.1 t ha^{-1} (Anonymous, 2015). Onion is an important and indispensable item in every Indian kitchen. Onion bulbs can be used as salad or cooked in various ways in all curries. It is also used in processed forms e.g. flakes, powder paste, pickles etc. It has very good medicinal value. Nutritive value of onion varies from variety to variety. It is a popular vegetable grown for its pungent bulbs and flavour of leaves. Pungency varies with growing condition, state of maturity and storage conditions. In Punjab onion is sown over an area in 2013–14 of about 8.3 thousand ha having production of 185.4 thousand t (Anon., 2015). Generally, the onion seeds are sown in nursery and transplanted with row to row spacing of 15 cm and plant to plant spacing of 7.5 cm to get optimum yield. During onion cultivation, transplanting of seedlings, weeding and harvesting are the most labour intensive operations that are presently done manually in India. The labour requirement in manual transplanting of onion seedlings is as high as 100–120 man-days ha^{-1} as 8.9 lakh seedlings ha^{-1} are to be transplanted (Rathinakumari et al., 2003). The area under onion cultivation is low and can be increased by mechanization of the sowing method.

Small and irregular shaped seeds lead to variation and placement of the seeds when existing planters are used. Due to this many times farmers resort to broadcasting of the seed. There is lack of mechanization in cultural practices in the areas where seed is broadcast. In areas where seed is broadcasted, there are issues of crop maintenance and management. This negatively affects the yield and cost of production. Therefore, increasing the yield and expanding the usage of mechanization in planting areas is a necessity, because of its uniform size and shape, pelleted seed is less likely to become stuck in mechanical planters, allowing growers too accurately and efficiently plant direct seeded crops. Accurate seeding and seed spacing makes thinning stands, at a later stage, easier or even unnecessary, leading to less seed waste and lower labour costs. Seed pelleting is the process of encapsulating a seed with small quantity of inert material just large enough to produce globular unit of standard size to facilitate precision planting. The inert material creates natural water holding media and provides small amount of nutrients to young seedlings (Scott, 1989; Krishnasamy, 2003). For the development of a mechanism for onion seed sowing the study of engineering properties of onion seeds is of utmost importance. Therefore, the physical properties of the onion seeds such as size, shape, test weight, angle of repose, bulk density and coefficient of static friction were studied. In recent years, physical properties have been studied for various crops such as locust bean seed (Ogunjimi et al., 2002); millet (Baryeh, 2002); quiona seed (Vilche et al., 2003) and almond nut and kernel (Aydin, 2003).

2. Materials and Methods

2.1. Selection of the varieties

The varieties of the onion seed is Punjab Naroya (PN), were selected for the study. Naroya was procured from the Director Seeds, Punjab Agricultural University, Ludhiana, India. Seeds were pelletized in different ratio according to seed weight and denoted by 1:1, 1:2 and 1:3 respectively. To study on its properties and comparison between un-pelleted seed and pelleted seed.

2.2. Seed pelletization

A seed pellet is a coating, usually of clay mixed with other inertmaterials that streamlines the size, shape, and uniformity of a small, non-round seed such as those of lettuce, carrots, onions, and many herbs and flowers. Pelleting results in easier, safer, and more accurate mechanical seeding, thus reducing gaps in the field and the need for labour-intensive thinning. Ideally, the pelleting materials are somewhat permeable to oxygen and absorb water quickly so that the pellet splits immediately upon hydration. Conventional pelleting techniques using synthetic inert materials are not approved for organic use, but there are now several pelleting materials in the market that are approved for use on organic farms.

The pelleting operation is generally performed on a batch basis and uses an inclined drum or coating pan (Scott, 1989, Ni, 1997). The pelleting process has become automated, and computer-controlled coating equipment has been described (Scott et al., 1997) In each case, seeds are coated with a combination of binder (adhesive) and tiller (bulking agent) Commercial coating formulations usually are blends of binders and tillers, and are formulated as dry powders The powder is sifted on to the seeds during the coating operation, and water is misted on. The water allows the formation of the pellet and also activates the adhesive Pelleting is a wet operation, so pellets must be dried at the completion of the coating process.

2.3. Sample preparation

Moisture content of the samples was determined according to AOAC approved vacuum oven method (AOAC, 1990). The seed moisture content ranged from 4.37–10.48% (d.b.) since transportation, storage and handling operations of the seeds are performed in this moisture range. All the experiments were replicated ten times and the average values were reported.

2.4. Size and shape of the seed

Olympus BX 61 microscope was used to measure the size of onion seeds. Olympus BX 61 microscope consisted of control box, motorized microscope, hand switch, data logger and a monitor. “Cell” imaging software for life science microscopy was used to measure the three principal axis of the seed. To acquire the image of the seed, the seed was placed in rest (horizontal) position over the glass slide and placed under the microscope. The image was focused sharply and clicked “snapshot” to obtain stationary image. Thereafter, the cell software was used to measure the two axis and thereafter the seed was rotated by 90° and the third axis was measured by repeating the same procedure. The dimensions of the randomly selected fifty seeds were measured for each variety. Further, geometric mean diameter (Dp) of the seeds were calculated using the following relationship (Mohsenin, 1970).

$$Dp = (\sqrt[3]{LWT}) \quad (1)$$

Where,

L=Length, mm

W=width, mm

T=thickness, mm

The Spherecity (Ψ) was calculated using the following equation (Mohsenin, 1970)

$$\Psi = (\sqrt[3]{LWT}/L) \quad (2)$$

2.5. Roundness

Roundness was measured by the trace of the seed is done on the graph paper and the area under the trace is measured by measuring the squares within it. The area of the closest circle in the seed area is also computed. The ratio of these two gives the roundness. Measuring roundness with callipers is slow and tedious. Seed property analyser calculates Roundness with following relationship.

$$Roundness=(W/L+T/L+T/W)/3 \quad (3)$$

2.6. Test weight

Test weight was determined for five random samples of each variety on an electronic balance having least count of 0.001 g. One thousand seeds were counted manually and thereafter weighed on an electronic balance.

2.7. Angle of repose

The angle of repose can be measured by measuring the height of the heap and the diameter of heap formed by the seeds (Kaleemullah and Gunasekar, 2002). For the determination of angle of repose of onion seed, a plastic cylinder (inner diameter

70 mm and height 270 mm) was kept vertically on horizontal wooden surface and filled with sample. Tapping during filling was done to obtain uniform packing and to minimize the wall effect, if any. The cylinder was slowly raised above so that whole material could slide freely to form a heap. The height of the heap (H) and the diameter of theheap (D) were measured with the help of measuring scale and the angle of repose (φ) of onion seed was computed using following relationship ((Bart-Plange and Baryeh, 2003; Mohsenin, 1980)

$$\varphi=\tan^{-1}(2H/D) \quad (4)$$

2.8. Bulk density, true density and porosity

The bulk density is the ratio of the mass of a sample of a seed to its total volume and it was determined with a weight per hectolitre tester which was calibrated in kg m^{-3} (Deshpande et al., 1993; Mohsenin, 1970). The porosity of bulk seed was calculated from bulk and kernel densities using the relationship given by Mohsenin (1970). A graduated measuring cylinder having an inner diameter 70 mm and height of 150 mm was filled with the prepared sample of onion seeds to a known volume. The filled sample was weighed using electronic weighing balance and the bulk density of the material filling the cylinder was computed. The kernel density of a seed is defined as the ratio of the mass of a sample of a seed to the solid volume occupied by the sample (Deshpande et al., 1993). The seed volume and its kernel density were determined using the liquid displacement method (Mohsenin, 1970; Sitkei, 1976). Toluene (C_7H_8) was used in place of water, because it is absorbed by seeds to a lesser extent and its surface tension is low, so that it fills even shallow dips in a seed and its dissolution power is low (Ogut, 1998). Then the known weight of the sample was poured in the graduated cylinder and displaced volume was noted. Ten replicates were conducted for each onion seed (Un-pelleted and pelleted 1:1, 1:2, 1:3). True density was calculated using the following equation.

$$TD=(W/V) \quad (5)$$

Where,

TD=true density (g cm^{-3}), W=Weight of sample (g), V=Displaced volume (cm^3)

The porosity is the measure of unconsolidated mass of material. It was calculated by using the using the following relation.

$$\text{Porosity}=(TD-BD)/TD \quad (6)$$

2.9. Coefficient of static friction

The coefficient of static friction of onion seed was determined on mild steel (MS) surface. A table top arrangement was used (Jha and Prasad, 1993; Jha, 1999; Sethi, 1989). The arrangement consists of a wooden box having dimensions of 10.5×10.5×5 cm^3, connected to a hanging weight carrier (pan) by means of string (having negligible mass) which passed over pulley of negligible friction fixed on one end of the table. The dimensions of the box (10.5×10.5×5 cm^3) was so selected to ensure that the total contact area of onion seed, with a horizontal surface is large enough to resist the force applied tangentially by sliding the whole mass rather than rolling should be sufficient to be measured easily. The wooden box was positioned on a horizontal MS surface. The weights were put into the pan until the box just started to slide. The total weight (W_1) was noted. The wooden box was then filled with onion seeds and was slightly raised above the floor to eliminate the effect of the rim of the wooden box in the value of static friction. Weights were again added to the hanging pan in small amounts until the box filled with seed began to just slide on the MS surface. The total weight (W_2) required to slide the box on the selected surface was recorded. The weight of the sample (W) was also noted and the coefficient of static friction was computed by the following expression.

$$\mu=(W_2-W_1)/W \quad (7)$$

3. Results and Discussion

3.1. Size and shape

The range of major, intermediate and minor dimensions of the onion seeds of cultivars Un-pelleted Pelleted 1:1, 1:2 and for the Pelleted 1:3 onion seeds are given in Table 1. For Un-pelleted onion seed the major dimension varied from 2.16-3.09 mm, intermediate dimension 1.4–2.74 mm, and the minor dimension 0.8–2.16 mm having mean values of 2.76, 1.97 and 1.47 mm, respectively. These values show that the onion seeds are not spherical. Microscopic view of the non-pelleted and

Table 1: Size of onion seeds of various cultivars studied

Variety		Un-pelleted	1:1 pelleted	1:2 pelleted	1:3 pelleted
M.D	R	2.16-3.09	2.85-3.63	2.35-4.16	2.95-4.65
	M	2.76	3.16	3.45	3.71
	SD	0.33	0.24	0.65	0.49
	CV%	11.84	7.73	18.82	13.33
ID	R	1.4-2.74	1.82-3.2	1.85-3.76	1.99-3.46
	M	1.97	2.32	2.76	2.88
	SD	0.43	0.39	0.65	0.47
	CV%	21.91	16.73	23.55	16.12
MD	R	0.8-2.16	1.42-2.58	1.82-3.37	1.8-3.42
	M	1.47	2.01	2.35	2.71
	SD	0.39	0.30	0.53	0.53
		26.80	14.95	21.00	19.69

M.D: Major Dimension; ID: Intermediate Dimension; MD: Minor Dimension; R: Range; M: Mean pelleted onion seed used for the study is shown in Figure 1. The geometric mean diameter as calculated from these dimensions and found to be 2.00, 2.45, 2.82 and 3.07 for Un-pelleted, Pelleted 1:1, 1:2 and 1:3 onion seeds respectively (Table 2).

The value of geometric mean diameter for 1:3 pelleted onion seeds was highest 3.07 and for the Un-pelleted it was least amongst the cultivars. The Spherecity as calculated using eq. 2 and it came out to be 0.72, 0.77, 0.81 and 0.82 respectively for Un-pelleted, Pelleted 1:1, 1:2 and 1:3 of onion seeds. The higher value of Spherecity in case of pelleted 1:3 seeds shows that these are nearly spherical in shape.

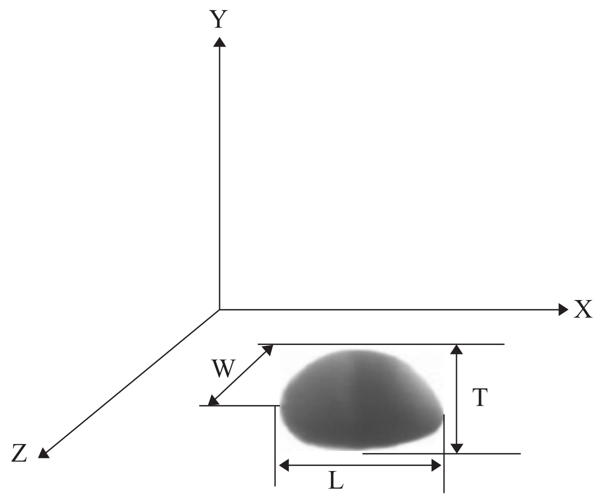

Figure 1: Characteristics Dimensions of Onion

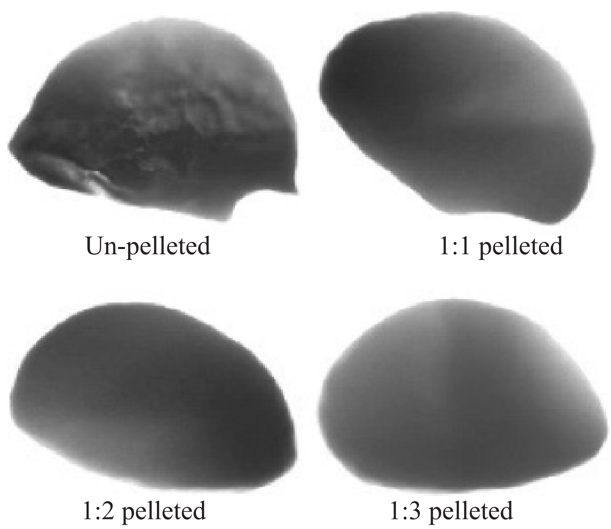

Figure 2: Microscopic view of non-pelleted and pelleted onion seed

3.2. *Test weight*

The test weight of onion seeds of the cultivars under study are given in (Table 3) Thus, there is considerable variation in the test weight of different cultivars. The average value of thousand grain weight was highest for the pelleted 1:1, 1:2 and1:3 onion seeds is 6.45, 9.95 and 13.21 g, as compared to the no-pelleted seeds is 2.37. Amongst the pelleted seeds the cultivar 1:3 has the highest thousand grain weight (13.21 g), followed by the cultivars 1:2 (9.95 g) and 1:1 (6.45 g).

3.3. *Angle of repose*

The average values of angle of repose for the cultivars under study as observed in the laboratory were 31.61°, 29.50°,

Table 2: Geometric mean diameter and sphere city of onion seeds of various cultivars studied

Variety		Un-pelleted	1:1 pelleted	1:2 pelleted	1:3 pelleted
GMD	R	1.65-2.61	2.01-3.06	2.01-3.74	2.19-3.53
	M	2.00	2.45	2.82	3.07
	SD	0.37	0.28	0.57	0.44
	CV%	18.71	11.81	19.80	14.55
S	R	0.60-0.84	0.67-0.85	0.71-0.93	0.70-0.96
	M	0.72	0.77	0.81	0.82
	SD	0.079	0.055	0.074	0.77
	CV%	11.11	7.20	8.88	9.41

GMD: Geometric mean diameter; S: Spherecity; R: Range; M: Mean

Table 3: Physical properties of onion seeds of various cultivars studied

Properties	Un-pelleted	Pelleted 1:1	Pelleted 1:2	Pelleted 1:3
Moisture content (%)	10.48	5.54	4.78	4.37
1000 seed test weight (g)	2.37	6.45	9.95	13.21
Attached material on 1000 seed (g)	-	4.08	7.58	10.84
Attached material on 1000 seed g^{-1}	-	2.72	4.20	5.57
Angle of repose (degree)	31.61	29.50	24.78	23.70
Bulk density (kg cm^{-3})	0.467	0.711	0.732	0.756
True density	1.00	1.25	1.28	1.42
Porosity	53.3	43.14	42.82	41.84
Roundness value	0.66	0.74	0.77	0.81
Coefficient of static friction	0.82	0.66	0.62	0.50
Germination (%)	84.33	85.66	90	87.33

24.78° and 23.70° for Pelleted onion seed (1:1, 1:2, 1:3) and un-pelleted onion seeds respectively. The lowest value of angle of repose was 23.70° for pelleted seeds 1:3 confirm near Spherecity of the pelleted seeds. The other seeds have nearly equal value of angle of repose. The pelletization of onion seed had significant effect on angle of repose.

3.4. Bulk density

The average value of bulk density was observed to be 0.467, 0.711, 0.732 and 0.756 g cm^{-3} for the seeds of Un-pelleted, Pelleted 1:1, 1:2 and 1:3 onion seeds respectively. Analysis of variance indicated that the bulk density differs significantly among the different seeds studied.

The average values of true density were 1.00, 1.25, 1.28 and 1.42 g cm^{-3} respectively for Un-pelleted, pelleted 1:1, 1:2 and 1:3 onion seeds. The values of porosity were 53.3, 43.14, 42.82 and 41.84 for the Un-pelleted, Pelleted 1:1, 1:2 and 1:3 seeds whereas the porosity for Un-pelleted seed was 53.3 and is the highest amongst the other cultivars.

3.5. Coefficient of static friction

The values for static friction for Un-pelleted, Pelleted 1:1, 1:2 and 1:3 onion Seeds were 0.82, 0.66, 0.62 and 0.50 respectively. The minimum value of coefficient of friction for pelleted 1:3 onion seeds confirms the near roundness of the pelleted seeds.

4. Conclusion

Some physical properties of onion seed for moisture content range of 4.78−10.48% (d.b.). The average width, thickness and geometric mean diameter of onion seeds increased and length values of onion seeds also increased with increase of pelleted material ratio of seeds. Sphere city, seed volume and seed surface area increased with increase of seed ratio. The pelleting of seeds no doubt improves the Spherecity of the seeds and hence the flow ability of seeds but at the same time increases the bulk density as well as true density of the seeds.

6. References

Anonymous, 2015. Available from http://www.Indiastat.com. Accessed on 10th July, 2015.

AOAC, 1990. Official methods of analysis of the AOAC (15th ed.). Arlington, VA: Association of Official Analytical Chemists, Inc.

Aydin, C., 2003. Physical properties of almond nut and kernel. Journal of Food Engineering 60, 315–320.

Bart-Plange, A., Baryeh, E.A., 2003. The physical properties of Category B cocoa beans. Journal of Food Engineering 60, 219–227.

Baryeh, E.A., 2002. Physical properties of millet. Journal of Food Engineering 51, 39–46.

Deshpande, S.D., Bal, S., Ojha, T.P., 1993. Physical properties of soybean seeds. Journal of Agricultural Engineering Research 56, 89–92.

Jha, S.N., 1999. Physical and hygroscopic properties of makhana. Journal of Agricultural Engineering Research 72, 145–150.

Jha, S.N., Prasad, S., 1993. Physical and thermal properties of gorgon nut. Journal of Food Process Engineering 16, 237–245.

Kaleemullah, S., Gunasekar, J.J., 2002. Moisture dependent physical properties of areca nut kernels. Biosystem Engineering 82(3), 331–338.

Mohsenin, N.N., 1970. Physical Properties of Plant and Animal Materials. New York: Gordon and Breach Science Publishers.

Mohsenin, N.N., 1980. Structure, physical characteristics and mechanical properties of plant and animal materials. Gordon and Breach Press, New York.

Ni, B.R., 1997. Seed coating, film coating and pelleting in Chinese Association of Agricultural Sciences, DOA, Ministry of Agriculture, PR China and China National Seed Group Corporation (Ed) Seed industry and agricultural development Beijing, China Agriculture Press 737–747.

Krishnasamy, V., 2003. Seed pelleting principles and practices, ICAR short course on seed hardening and pelleting technologies for rainfed/garden land ecosystems, May 27 to June 5, pp 96. Tamil Nadu Agricultural University, Coimbatore, India.

Ogut, H., 1998. Some physical properties of white lupin. Journal of Agricultural Engineering Research 69, 237–277.

Ogunjimi, L.A.O., Aviara, N.A., Aregbesola, O.A., 2002. Some engineering properties of locust bean seed. Journal of Food Engineering 55, 95–99.

Rathinakumari, A.C., Mandhar, S.C., Gowda, R.H., 2003. Development of drum seeders for onion. Downsizing Technology for Rural Development 1, 31–37.

Scott, J.M., 1989. Seed coatings and treatments and their effects on plant establishment. Advances in Agronomy 42, 43–83.

Scott, J.M., Blair, G.J., Andrews, A.C., 1997. The mechanics of coating seeds in a small rotating drum Seed Science and Technology 25, 281–292.

Sethi, P.S., 1989. Selected engineering properties of oilseeds commonly grown in Punjab. M. Tech thesis Punjab Agricultural University, Ludhiana, India.

Sitkei, G., 1976. Mechanic of Agricultural Materials. Budapest: Akademia Kiado.

Vilche, C., Gely, M., Santalla, E., 2003. Physical properties of quinoa seeds. Biosystems Engineering 86(1), 59–65.