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Frictional, Mechanical and Aerodynamic Properties of Onion Seeds

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ABSTRACT

Some of the frictional, mechanical and aerodynamic properties of onion seeds needed for design of onion umbels thresher were identified, determined and reported as a function of moisture content in the range of 9.8-29.6% (db). As the moisture content increased from 9.8% to 29.6% (db), the angle of repose and terminal velocity were found to increase from 28.11 to 37.41^{o} and 1.7 to 2.6 m/s, where as rupture force was found to decrease from 116.73 to 40.14 N, respectively. The static coefficient of friction of onion seeds increased for all four surfaces, namely, plywood (0.5191-0.6381), mild steel (0.4259-0.5976), galvanized iron (0.4334-0.5781) and stainless steel (0.2878-0.4981) as moisture content increased from 9.8 to 29.6% (db).

Key words: Onion seed, mechanical properties, rupture force, terminal velocity

INTRODUCTION

Bellary onion (*Allium cepa var.cepa*) and multiplier onion (*Allium cepa var. aggregatum*) are the two major onion groups cultivated in India. Tamil Nadu accounted for 5 per cent of country's area under onion and more than 70 per cent of this is shared by small onion. According to the Second Advance Estimates (2012-13) of National Horticultural Board, area and production of onion in Tamil Nadu were 36,310 ha and 3,98,930 tonnes, respectively and in the year 2011-12, they were 37,120 ha and 5,56,450 tonnes, respectively. Farmers are of the opinion that crop duration, lesser cost of cultivation, storability and better profits compared to other crops lead them to prefer onion instead of other crops. Most of the small onions are cultivated using the onions but even small onions can be cultivated using the seeds as like big onions (bulb). CO (On) 5 is the high yielding variety, with attractive pink and bold bulbs, is a free- flowering type with seed setting ability. It can be propagated through seeds as well as bulbs. The major CO (On) 5 crop growing district in Tamil Nadu are Perambalur, Trichy, Dindigul, Namakkal, Coimbatore, Erode and Tirunelveli. The yield of the CO (On) 5 is higher (18 t/ha) as compared to other varieties, that's why the onion growing farmer in Tamil Nadu prefer this Variety.

The frictional properties such as coefficient of friction and angle of repose are important in designing of storage bins, hoppers, chutes, pneumatic conveying system, screw conveyors, forage harvester, threshers etc., (Sahay and Singh, 2004). The frictional loss is one of the important factor, which must be overcome by providing additional power to the machine. Mechanical properties of seeds vary extensively with its moisture content and are important to the process or product designers (Ghasemlou *et al.*, 2010). The mechanical damage to grain and seed in threshing and handling operations causes reduction in germination power and viability of seeds (Mohsenin, 1980). The aerodynamic property such as terminal velocity of agricultural products is important and required for designing of separation equipment (Sahay and Singh, 2004).

The objective of study was to investigate important moisture-dependent frictional, mechanical and aerodynamic properties of onion seeds namely, angle of repose, static coefficient of friction against different surfaces, rupture force and terminal velocity in the moisture range of 9.8-29.6% (db).

MATERIALS AND METHODS

Raw material

Onion seeds (CO 5 variety) were obtained from local onion seed growing farmer in Coimbatore and used for the study. The seeds were cleaned manually to remove all foreign materials such as dust, dirt, broken flower parts and chaff as well as immature and damaged seeds.

Sample preparation and moisture content determination of onion seed

The initial moisture content of the onion seed was determined using hot air oven at 105 ± 1˚C until a constant weight was reached (Suthar and Das, 1996). The initial moisture content of seeds was found to be 9.8 % (db). In order to achieve the desired moisture levels for the study, onion seeds samples were conditioned by adding calculated quantity of water based on Equation (1) (Dursun and Dursun, 2005) followed by a thorough mixing and sealing in plastic bags.

$$Q = \frac{W_i (M_f - M_i)}{100 - M_f} \qquad \ldots (1)$$

Where, Q is the mass of water to be added in kg; W_i is the initial mass of the sample in kg; M_i is the initial moisture content in per cent (db) and M_f is the final moisture content of the sample in per cent (db). The moisture contents of the samples were equilibrated to 9.8, 14.6, 19.3, 24.6 and 29.6% (db) as per the procedures outlined in AOAC (1995). The required quantity of sample was withdrawn and equilibrated at room temperature (30±2°C) before conducting different tests.

Angle of repose

The filing angle of repose was determined using the apparatus described by Sreenarayanan *et al.* (1988). Angle of repose was determined from the height and diameter of the naturally formed heap of seed on a circular plate. The angle of repose was calculated from the following equation

$$\theta = \tan^{-1}\left(\frac{2H}{D_h}\right) \qquad \ldots (2)$$

Where, θ - angle of repose, degree; H - height of the heap, mm; D_h – diameter of the disc, mm.

Co-efficient of static friction

The apparatus used for the determination of co-efficient of static friction (μ) in the study consisted of a frictionless pulley fitted on a frame, a bottomless cylindrical container, a loading pan and test surfaces. The bottomless container was placed on the test surface, filled with onion seeds of known weight and weights were added on the loading pan until the container began to slide. The weight of the onion seed and the weights added on the loading pan represented normal force (N) and lateral force (F), respectively. The co-efficient of static friction was calculated as given below

$$Co-efficient\ \ of\ \ friction\ (\mu)=\frac{F}{N} \qquad \ldots \qquad (3)$$

Where,

F- Lateral force, g and

N- Normal force, g

The experiment was performed on different test surfaces like plywood, galvanised iron, mild steel and stainless steel. Each time, the experiment was conducted thrice and the average value was determined and recorded as co-efficient of friction.

Rupture force

Rupture force of onion seed were determined with the help of texture analyzer. Each moisture content level, twenty five seeds were tested and the mean value was taken.

Terminal Velocity

Terminal velocity was measured by using a seed blower (air column system). For each experiment, a seed was dropped into the air stream from the top of the air column, in which air was blown to suspend the seed in the air stream. The air velocity near the location of the seed suspension was measured by a hot wire anemometer having a least count of 0.01 m/s (Ghasemlou *et al*., 2010).

RESULTS AND DISCUSSION

Angle of repose

Angle of repose of onion seed was determined at different moisture contents and their relationship is shown in Fig. 1. From the figure, it is seen that the angle of repose was found to increase with increase in moisture content linearly from 28.11 to 37.41^{o} for the increase in moisture content from 9.8 to 29.6% (db). The relationship between moisture content and angle of repose was linear and positive. From the figure, it is also seen that 66.9 per cent change in moisture content changed only 24.86 per cent in angle of repose. The increase in angle of repose of onion seeds with increase in moisture content may be due to increase in internal friction with increase in moisture contact.

The values of angle of repose for onion seeds for different moisture content followed a linear regression equation of the form

$$\theta = 0.4193M + 25.383, \quad (R^2 = 0.9872) \qquad \dots (4)$$

Where,

θ - angle of repose of onion seeds, degree and

M - moisture content of onion seeds, per cent (db).

Similar trend was observed by Singh and Goswami (1996) in cumin seeds, Suthar and Das (1996) in karingda seeds and kernels, Aviara *et al.* (1999) in guna seeds, Nimkar and Chattopadhyay (2001) in green gram, Baryeh (2002) in bambara groundnuts, Sahoo and Srivastava (2002) in okra seeds, Amin *et al.* (2004) in lentil seeds, Dursun and Dursun (2005) in caper seeds, Nimkar *et al.* (2005) in moth grain and Singh *et al.* (2009) in barnyard millet grain and kernel. This confirmed the findings of the present study.

Co-efficient of friction

The effect of moisture content of onion seeds on coefficient of static friction against various test surfaces, namely, plywood, mild steel, galvanized iron and stainless steel is depicted in Fig. 2. From the figure, it is seen that the static coefficient of friction of onion seeds increased from 0.5191 to 0.6381 on plywood surface, 0.4259 to 0.5976 on mild steel surface, 0.4334 to 0.5781 on galvanized iron surface and 0.3340 to 0.4981 on stainless steel surface for the change in moisture contents from 9.8 and 29.6 per cent (db). The plywood surface offered the maximum friction followed by mild steel, galvanized iron and stainless steel. This may be due to more roughness of plywood surface as compared to stainless steel.

The variation in co-efficient of friction with moisture content of onion seeds on different surfaces followed a linear relationship and represented by regression equations as given below.

$$\mu_P = 0.0059M + 0.4707, \quad (R^2 = 0.9678) \qquad \dots (5)$$

$$\mu_M = 0.0086M + 0.3464, \quad (R^2 = 0.9961) \qquad \dots (6)$$

$$\mu_G = 0.0074M + 0.3627, \quad (R^2 = 0.9928) \qquad \dots (7)$$

$$\mu_S = 0.0085M + 0.2594, \quad (R^2 = 0.9716) \qquad \ldots (8)$$

Where,

μ_P – coefficient of static friction of onion seeds on plywood, fraction

μ_M – coefficient of static friction of onion seeds on mild steel, fraction

μ_G – coefficient of static friction of onion seeds on galvanized iron, fraction

μ_S – coefficient of static friction of onion seeds on stainless steel, fraction

M - moisture content of onion seeds, per cent (db)

The reason for the increased coefficient of static friction at higher moisture content may be due to higher cohesive force present between onion seeds at higher moisture content. Similar results were reported by Aviara *et al*. (1999) for guna seeds, Kaleemullah (2002) for chillies and Singh *et al*. (2009) for barnyard millet grain and kernel which confirmed the findings of present study.

Rupture force

The force required to rupture (break) onion seeds decreased from 116.73 to 40.14 N with increase in moisture content from 9.8 to 29.6% (db) as shown in Fig. 3. This decrease in rupture force may be due to softening of the seeds at higher moisture contents. The change in rupture force of onion seeds with change in moisture content followed a linear regression equation of the form

$$F = 146.42\text{-}3.7528M, \quad (R^2 = 0.9588) \qquad \ldots (9)$$

Where,

F- Rupture force, Newton and

M- Moisture content of onion seeds, per cent (db)

Similar trend in rupture force was observed by Joshi *et al.* (1993) in pumpkin seeds and Singh *et al.* (2009) in barnyard millet grains.

Terminal velocity

From the figure 4, it is seen that the terminal velocity of onion seeds increased from 1.7 to 2.6 m/s with increase in moisture content from 9.8 to 29.6 per cent (db). A linear relationship is seen between the moisture content and the terminal velocity of onion seeds. The relationship between moisture content and terminal velocity (V_t) can be represented by a regression equation of the form

$$V_t = 0.0462M + 1.1618, \quad (R^2 = 0.9581) \qquad \ldots (10)$$

Where,

V_t - terminal velocity of onion seeds, m/s and

M - moisture content of onion seeds, per cent (db)

A R^2 value of 0.9581 shows the best fit of equation to the experimental values. The increase in terminal velocity with increase in moisture content may be attributed to the increase in mass of an individual seeds per unit frontal area presented to the air stream. However, increase in weight due to increase in moisture content was higher than the increase in projected area, which required more force to lift and suspend the seeds in the air column and hence exhibited higher terminal velocity. Similar trend of increase in terminal velocity with increase in moisture content was observed by Nimkar and Chattopadhyay (2001), Konak *et al.* (2002), Sacilik *et al.* (2003), Rajabipour *et al.* (2006), Gupta *et al.* (2007), Tunde *et al*. (2007), Singh *et al.* (2009) and Ghasemlou *et al.* (2010) in green gram, chick pea seeds, hemp seeds, wheat, sunflower seeds, lemon seeds, barnyard millet grains and mungbean seeds, respectively. This confirmed the findings reported in the present study.

CONCLUSIONS

CO 5 is the most popular onion seed variety grown in Tamil Nadu. According to onion seed traders, more than 30 per cent area sown was under hybrid onion CO 5 seed and raised using onion seeds. Frictional, mechanical and aerodynamic properties are important for designing an onion umbel cutter, onion seed extractor and onion seed cleaner. Moisture dependent frictional properties studied namely angle of repose and static coefficient of friction increased with increase in moisture content. Terminal velocity also increased with increase in moisture content, where as rupture force was found to decrease with increase in moisture content from 9.8 to 29.6 % (db). Separation of seeds using terminal velocity, one of the aerodynamic properties plays an important role in accomplishing cleaning of onion seeds from the broken flower parts of umbels and other broken threshed trashes. The static coefficient of friction on various surfaces, namely, plywood, mild steel, galvanized iron and stainless steel also increased linearly with increase in moisture content. The plywood surface offered the maximum friction followed by mild steel, galvanized iron and stainless steel.

REFERENCES

Amin, M.N., Hossain, M. A. and Roy, K. C. 2004. Effect of moisture content on some physical properties of lentil seeds. J. Food Eng., 65, 83-87.

AOAC. 1995. Official methods of analysis. Washington DC: Association of Official Analytical Chemists.

Aviara, N.A., Gwandzang, M. I. and Hque, M. A. 1999. Physical Properties of Guna Seeds. J.Agric. Eng. Res., 73(2), 105-111.

Baryeh, E. A. 2001. Physical properties for Bambara groundnuts. J. Food Eng., 47, 321-326.

Dursun, E and Dursun, I. 2005. Some physical properties of caper seed. Biosystem Eng., 92, 237-245.

Gupta, R. K., Arora, G. and Sharma, R. 2007. Aerodynamic properties of sunflower seed (*Helianthus annuus L*.). J. Food Eng., 79, 899-904.

Joshi, D.C., Dass, S. K. and Mukherjee, R. K. 1993. Physical properties of pumpkin seeds. J. Agric. Eng. Res., 54, 219-229.

Kaleemullah, S. 2002. Studies on engineering properties and drying kinetic of chillies. Unpublished Ph.D Thesis,Tamil Nadu Agricultural University, Coimbatore, India.

Konak, M., Carman, K. and Aydin, C. 2002. Physical properties of chickpea seeds. *Biosystem Engineering* 82(1): 73-78.

Ghasemlou, M., Faramarz, K., Seyed, M.T.G., Moayedi, A. and Keshavarz, B. 2010. Study on Postharvest Physico-Mechanical and Aerodynamic Properties of Mungbean [*Vigna radiate (L.) Wilczek*] Seeds. Int. J. Food Eng., 6 (6).

Mohsenin, N.N. 1980. Physical properties of plant and animal Materials. Gordon and Breach Science Publishers, New York.

Nimkar, P.M. and Chattopadhyay, P. K. 2001. Some physical properties of green gram. J. Agric. Eng. Res., 80 (2), 183-189.

Nimkar, P.M., Mandwe, D.S. and Dudhe, R.M. 2005. Physical properties of moth gram. Biosystems Eng., 91 (2), 183-189.

Rajabipour, A., Tabatabaeefar, A. and Farahani, M. 2006. Effects of moisture on terminal velocity of wheat varieties. *International Journal of Agriculture and Biology* 8(1):0-13.

Sacilik, K., Ozturk, R. and Keskin, R. 2003. Some physical properties of hemp seed. Biosystems Eng., 86, 191 198.

Sahay, K. M. and Singh, K.K. 2004. Unit operations of Agricultural processing. Vikas Publishing House Private Limited, Delhi-110 014.

Sahoo, P. K. and Srivastava, A. P. 2002. Physical properties of okra seed. Biosystems Eng., 83, 441-448.

Singh, K.K. and Goswami, T.K. 1996. Physical properties of cumin seed. J. Agric. Eng. Res., 64, (2), 93-98.

Singh, K.P., Mishra, H.N. and Supradip, S. 2009. Moisture-dependent properties of barnyard millet grain and kernel. J. Food Eng., 96, 598-606.

Sreenarayanan, V.V. Viswanathan, R. and Subramanaiyan, V. 1988. Physical and thermal properties of soybean. J. Agric. Eng. Res., 25 (4), 76-82.

Suthar, S.H. and Das, S.K. 1996. Some Physical properties of karingda (Citrullus lamatis (Thump Manif)] seeds. J. Agric. Eng. Res., 65, 15-22.

Tunde, T.Y.A., Akintunde, B.O. and Oyelade, O.J. 2007. Effect of moisture on terminal velocity, compressive force and frictional properties of melon seed. *Agricultural Engineering International: the CIGR Ejournal.* Manuscript FP 07 022.

FIGURES

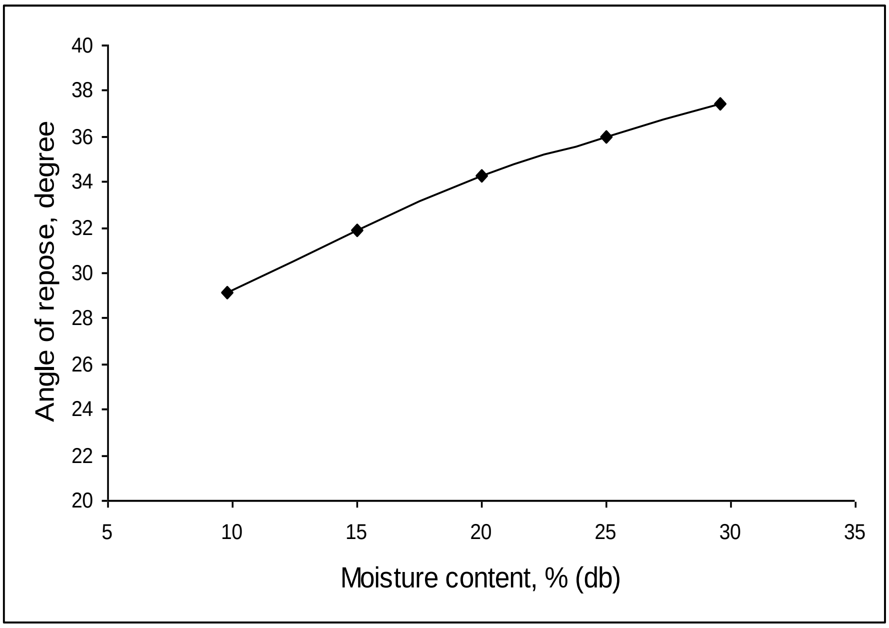

Fig. 1. Effect of moisture content on angle of repose of onion seeds

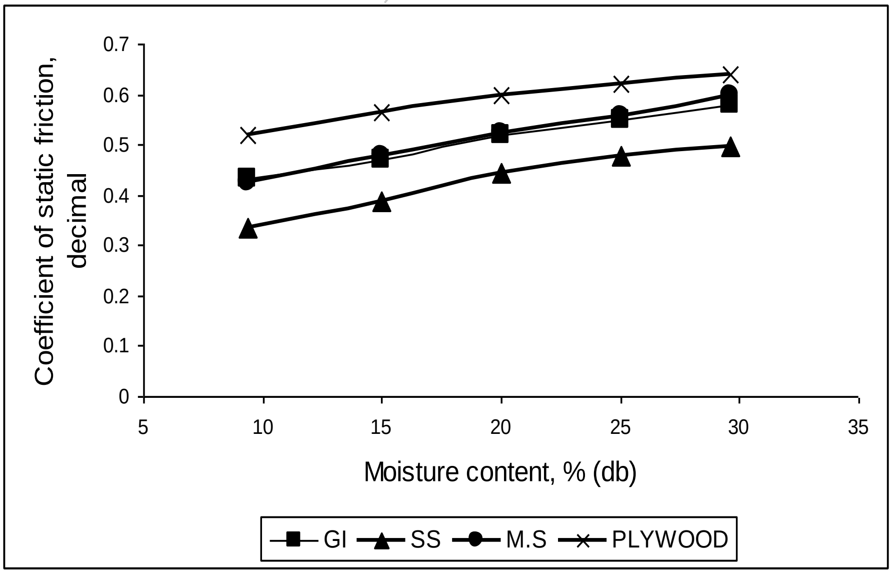

Fig. 2: Effect of moisture content on static coefficient of friction of onion seeds on different surfaces

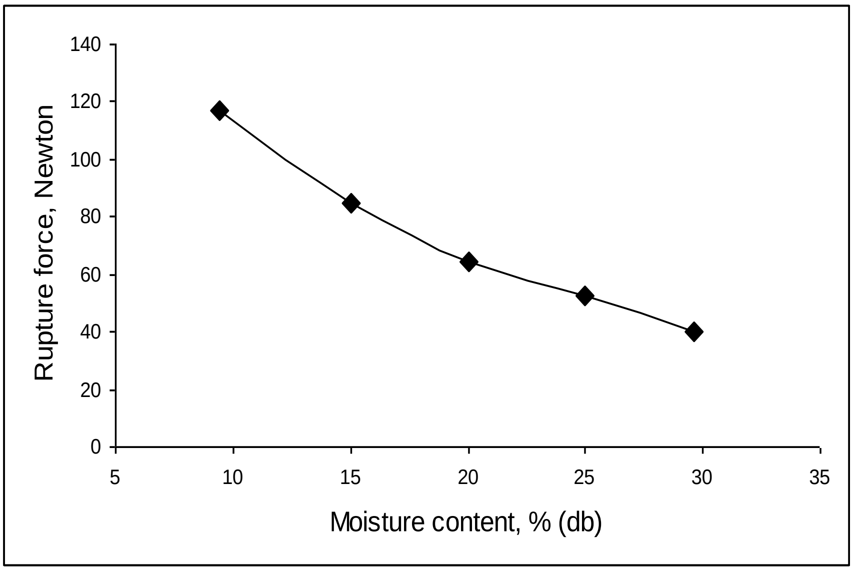

Fig. 3. Effect of moisture content on rupture force of onion seeds

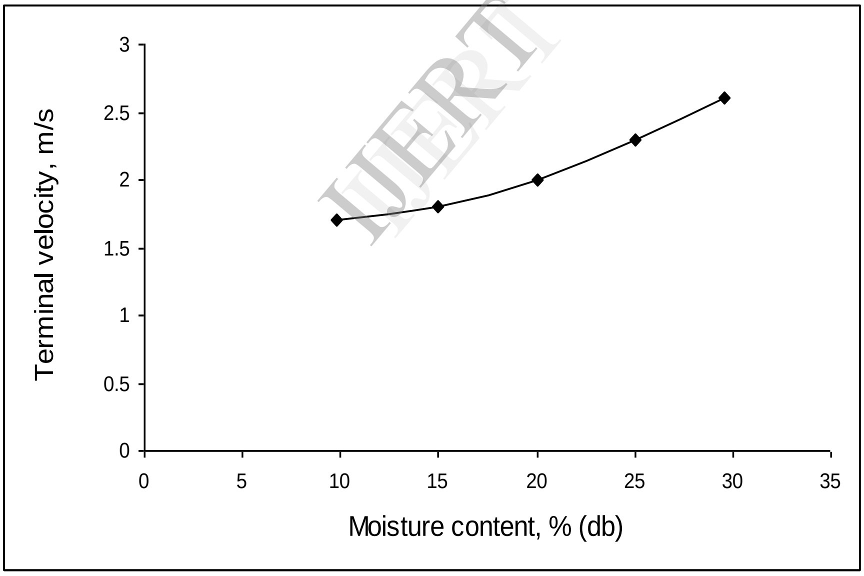

Fig. 4. Effect of moisture content on terminal velocity of onion seeds