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EFFECT OF MOISTURE CONTENT ON GRAVIMETRIC AND FRICTIONAL PROPERTIES OF RIDGE GOURD SEED (*Luffa Actangula Roxb*)

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Abstract: The present study was undertaken with five moisture levels (8%, 12%, 16%, 20% and 24%), whose effect was studied on gravimetric and frictional properties of ridge gourde seed. The gravimetric properties such as thousand grain weight, single grain weight and porosity increased linearly with increase in moisture content from 8 to 24% except bulk density and kernel density showed a decreasing trend. The frictional properties such as angle of repose and coefficient of static friction also increased linearly with increase in moisture content. The thousand grain weight, volume of single grain, bulk density, kernel density and porosity of ridge gourd were found to be 137.65 gm, 0.145 cc, 0.666 gm·cc^{-1}, 1.124 gm·cc^{-1} and 40.75% respectively. The angle of repose was 24.16^0 and coefficient of static friction varied between 0.40 to 0.47 (due to various surfaces). The relationship between moisture content and various gravimetric and frictional properties was also established.

Key words*: Thousands grain weight, bulk density, kernel density, porosity, angle of repose and coefficient of static friction, moisture content*

INTRODUCTION

Ridge gourd (*Luffa Actangula Roxb*) is one of the vegetable cultivated, in the tropics. It is commonly grown all over India but it is more popular in the south and the east. It is also called angled gourd, angle loofah. Ridge gourd fruits are cooked as a vegetable and their seeds are rich in protein and oil. It contains 95.2 gm moisture, 0.1 gm

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fat, 0.5 gm fiber and 0.5 gm protein. Ridge gourd originated in India the production of gourd, pumpkin and squash in India is 33.50 lakh metric tons on an area of 3.50 lakh ha [6]. Gravimetric and frictional properties are the engineering properties of ridge gourd seed. Engineering properties of ridge gourd seed are important in the design of storage structure and processing equipments. The information regarding gravimetric properties of ridge gourd seed is useful for design and analysis of separation and drying equipments. Frictional properties such as angle of repose and coefficient of static friction are used in the design of storage structure.

MATERIAL AND METHODS

The ridge gourd seed var. Phule Sucheta were cleaned and graded with top screen size 9.50 mm and bottom screen size of 6.40 mm round hole with cleaner cum grader (make OSAW Agro. Industries, Hariyana, Capacity 50 to 100 $kg{\cdot}hr^{-1}$) in the month of Mar 2003 in Agricultural Process Engineering laboratory, at M.P.K.V, Rahuri The initial moisture content of the ridge gourd seed was determined. The samples were further prepared of different moisture contents by conditioning grains. The prediction equations for the effect of moisture content on the engineering properties were developed. Statistical analysis was done using completely randomized design (C.R.D) to test the significance of moisture content on different properties.

Different levels of moisture content (wb) considered in this study were 8, 12, 16, 20 and 24. Half kg of cleaned and graded ridge gourd seeds were used as test material and five replications were taken. The cleaned seeds were conditioned for desired level of moisture content. The test material was then allowed to equilibrate in the airtight stored in a refrigerator for 72 hrs. The actual moisture content of sample was then determined after conditioning.

Gravimetric Properties

Volume of single grain:

Volume of single grain was determined using tolune displacement method by Mohsenin (1970) [7].

$$Volume\ single\ grain = \frac{Volume\ of\ displaced\ tolune}{Number\ of\ grains} \qquad (1)$$

Thousand grain weight:

Five samples of 1000 seeds were taken and weighed on precision balance.

Bulk density:

Bulk density of ridge gourd seed was determined by using a 500cc conical glass graduated cylinder used for measuring volume of the sample. The seeds were slowly poured into a measuring cylinder up to its full capacity. Then weight of grain sample was taken using an electronic balance. Then bulk density of sample was calculated by:

$$Bulk\ density = \frac{Weight\ of\ Sample}{Volume\ of\ Sample} \quad (2)$$

Kernal Density:

Kernal density was determined by using tolune displacement method (Mohsenin 1970) [7]. Five gram of sample was taken into relative density (RD) bottle. About 20 cc of tolune was poured in RD bottle such that sample was fully submerged. Four such RD bottles were kept in vacuum desiccators. One Hp vacuum pump was used to extract the entrapped air in between sample particles. A suction part of pump was connected with the help of plastic pipe of 10 mm in diameter. The vacuum pump was run to extract air by suction. After 15 min settled particles were gently stirred and again air was sucked out. When there was no bubble coming out, the pump was stopped.

Relative density bottles were further filled up to their capacities. The weight of the RD bottles along with sample and tolune was taken. Then RD bottles were emptied and carefully washed. The RD bottles were again filled with water up to full capacity weighed. The weight of empty RD bottle was takes. The kernel density was calculated by:

$$Specific\ gravity\ of\ tolune = \frac{(W_3 - W_2)}{(W_5 - W_2)} \quad (3)$$

$$Kernel\ density\ of\ seeds = \frac{Specific\ gravity\ of\ tolune\ \ X\ \ W_1}{(W_1 - (W_4 - W_3))} \quad (4)$$

Where:

W_1 [gm] - weight of sample,
W_2 [gm] - weight of RD bottle,
W_3 [gm] - weight of RD bottle + weight of tolune,
W_4 [gm] - weight of RD bottle + weight of tolune + weight of sample,
W_5 [gm] - weight of RD bottle + weight of water.

Porosity:

Porosity of unconsolidated mass of material was determined by:

$$Porosity = 1 - \frac{B.D}{K.D} x 100 \quad (5)$$

Where:

B.D. [g·cc^{-1}] - bulk density,
K.D. [g·cc^{-1}] - kernel density.

Frictional Properties

Angle of Repose:

Angle of repose of seeds was calculated by the formula:

$$\Theta_R = \frac{tan^{-1} 2(H_c - H_p)}{D_p} \quad (6)$$

Where:
Θ_R [deg] - angle of repose,
H_c [cm] - height of pile,
H_p [cm] - height of platform,
D_p [cm] - diameter of circular platform.

Coefficient of static friction:

Coefficient of static friction was determined for various surfaces viz. glass, steel and asbestos using the method given by. Surfaces were attached to tilting table one at a time then the sample was placed on the surface. The table was then slowly tilted until the sample started to slide. The angle of tilting table was measured. The coefficient of static friction was calculated as tangent of angle measured.

Data was analyzed using completely randomized design (C.R.D) and the graphs were plotted. The linear mathematical models were developed to correlate the moisture content with the properties on the basis of the correlation coefficient. The best-fit equation with maximum regression coefficient was selected for prediction.

RESULTS AND DISCUSSION

The effect of moisture content on gravimetric and frictional properties of ridge gourd seed (Var. *Phule Sucheta*) was studied and is tabulated in Tab. 1 and Tab. 2, which gives the data on the effect of moisture content on the gravimetric and frictional properties of ridge gourd seed.

Gravimetric Properties

Volume of single grain:

Fig. 1 shows the effect of moisture content on the volume single grain. Volume of single grain weight increased from 0.145 to 0.223 cc for moisture content variation from 8 to 24%. The swelling of grain due to absorption of moisture resulted in increase in volume. The increase in volume with increase in moisture content was reported for niger seed by Bhanuwanshe *et al.,* (1997) [1] and Munde (2000) [4]. The effect was significant at all levels. The mathematical model developed was of form as given below (R^2 = 0.98849).

$$V_s = 0.0948 = 0.0057\,M \tag{7}$$

Thousand grain weight:

Fig. 2 shows the effect of moisture content on the thousand grain weight. Thousand grain weight increased from 137.65 to 171.27 gm with increase in moisture content from 8 to 24 %. This was due to absorption of moisture by grains. The variation of thousand-grain weight was significant for all moisture levels. The increase in moisture content increased thousand grain weight was also reported for gram, horse-gram, niger seed by

Datta *et al.* (1988) [2], Munde (2000) [4] and Banuwanshe *et al.* (1997) [1] respectively. Thousand grain weight at different moisture levels can be predicted by (R^2 = 0.9356).

$$W_{1000} = 124.85 = 1.861M \tag{8}$$

Table 1. Effect of moisture content on gravimetric properties

Moisture content [% w. b.]	1000 grain weight [gm]	Volume of single grain [cc]	Bulk density [g·cc^{-1}]	True density [g·cc^{-1}]	Porosity [%]
8	137.65	0.145	0.666	1.124	40.75
12	148.00	0.160	0.590	0.998	40.88
16	155.66	0.187	0.540	0.935	42.24
20	161.00	0.212	0.513	0.900	43.00
24	171.27	0.233	0.485	0.880	44.87
S.E. ±	3.164155	5.5785E-03	4.0917E-03	1.7794E-03	0.4462518
C. V. (%)	2.045058	2.976784	0.7322766	0.1838508	1.05136

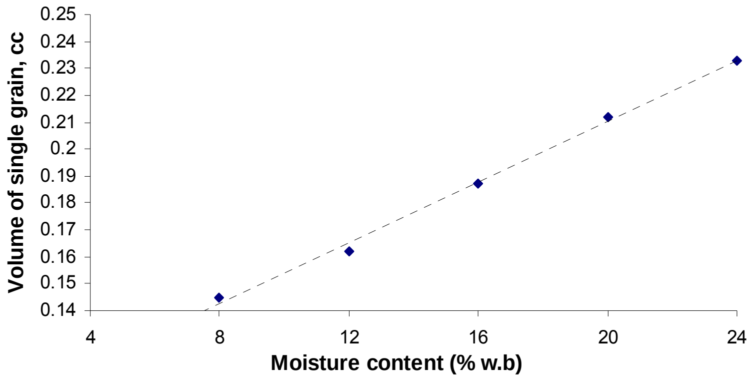

Figure 1. Effect of moisture content on volume of single grain

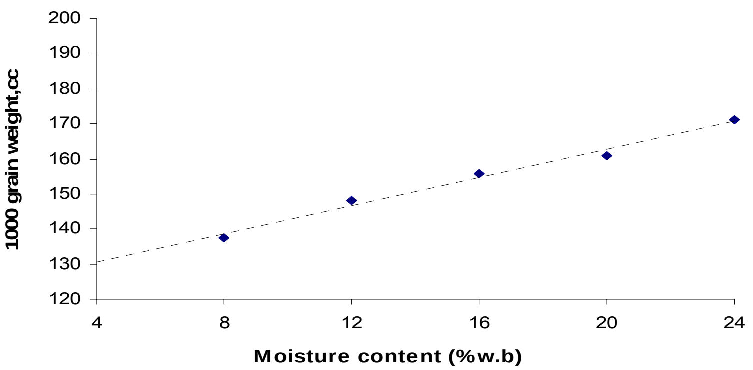

Figure 2. Effect of moisture content on 1000 grain weight

Thousand grain weight:

Fig. 2 shows the effect of moisture content on the thousand grain weight. Thousand grain weight increased from 137.65 to 171.27 gm with increase in moisture content from 8 to 24 %. This was due to absorption of moisture by grains. The variation of thousand-grain weight was significant for all moisture levels. The increase in moisture content increased thousand grain weight was also reported for gram, horse-gram, niger seed by Datta *et al.* (1988) [2], Munde (2000) [4] and Banuwanshe *et al.* (1997) [1] respectively. Thousand grain weight at different moisture levels can be predicted by (R^2 = 0.9356)

$$W_{1000} = 124.85 = 1.861M \quad (9)$$

Bulk density and Kernel density:

Fig. 3 shows the relationship between bulk density and kernel density verses moisture content. It was observed that the bulk density decreased from 0.666 to 0.485 gm·cc^{-1} and kernel density decreased from 10124 to 0.880 gm·cc^{-1}, due to increase in moisture. Mass and bulk volumes both are increased due to absorption of moisture by the seed. However, increase in bulk volume is more pronounced and hence there is decrease in bulk density. In addition in case of kernel density, rate of increase in volume is more and hence there is effective decrease in kernel density. Similar results were reported for pigeon pea and gram by Shephard and Bharadwaj (1986) [5] and Dutta *et al.* (1988) [2].

The mathematical models for bulk density were as under (R^2 = 0.9464, 0.8875)

$$B.D. = 0.7344 - 0.011M \quad (10)$$

$$K.\ D. = 1.2018 - 0.0014M \quad (11)$$

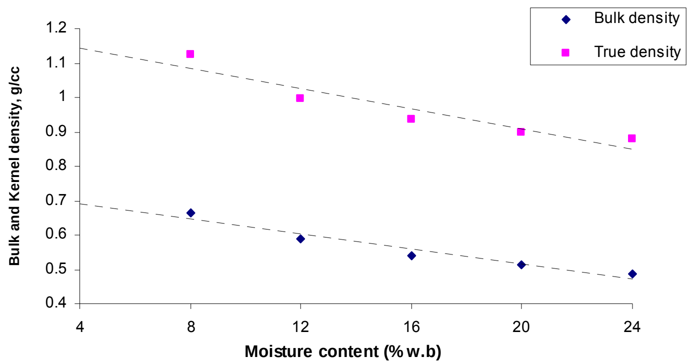

Figure 3. Effect of moisture content on bulk and kernel density

Porosity:

Fig. 4 shows the variation of porosity with moisture content. The data is statistically significant for all moisture levels. The porosity increased from 40.75 to 44.87% with increase in moisture content. Similar results were reported by Dutta *et al.* (1988), Shephard and Bharadwaj (1986) [5] and Kanawade and Dhingra (1982) [3]. The mathematical model for porosity was as under (R^2 = 0.9356)

$$P_0 = 38.214 = 0.2585M \tag{12}$$

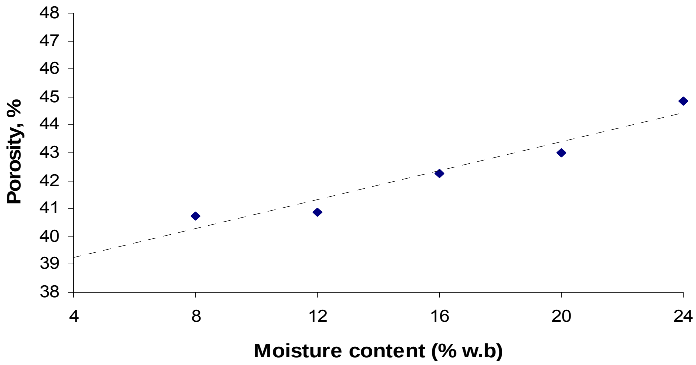

Figure 4. Effect of moisture content on porosity

Frictional properties:

The data on variation in angle of repose and coefficient of static friction with moisture content are presented in Tab. 2.

Table 2. Effect of moisture content on frictional properties

Moisture content [% w. b.]	*Angle of repose [deg]*	*Coefficient of static friction*		
		Glass	*Steel*	*Asbestos*
8	*24.16*	*0.40*	*0.43*	*0.47*
12	*32.08*	*0.41*	*0.46*	*0.50*
16	*36.90*	*0.43*	*0.48*	*0.53*
20	*39.89*	*0.45*	*0.52*	*0.55*
24	*40.38*	*0.47*	*0.55*	*0.59*
S.E. ± *C. V. (%)*	*0.613822* *1.773*	*5.05931E-03* *1.171137*	*3.68709E-02* *0.7567916*	*6.06688E-03* *1.1534*

Angle of repose:

Fig. 5 represents the variation in angle of repose with moisture content. It was observed that the angle of repose increased with increase in moisture content from 24.16^0 to 40.38^0. The variation of angle of repose with moisture content was due to layer of moisture that surrounds each grain and the surface tension effect becomes predominant in holding the aggregates of solids together. Similar results were reported for gram, niger seed, fababean and pigeon pea by Dutta *et al.* (1988) [2], Bhanuwanshe *et al.* (1997) [1] and Munde (2000) [4]. The angle of repose is predicted by equation (R^2 = 0.8924).

$$R = 1.8662 + 0.9983M \tag{13}$$

Coefficient of Static friction:

Fig. 6 represents the graphical representation of variation of coefficient of static friction with moisture content. It was observed that coefficient of static friction was 0.40, 0.43 and 0.47 at 8% moisture content and 0.47, 0.55 and 0.57 at 24 % moisture content for glass, steel and asbestos respectively. The presence of moisture on rubbing surface caused an increase in friction due to increase in adhesion, resulting in increase in coefficient of static friction. The effect of the moisture content on coefficient of static friction was found to be statistically significant at 5% level of significance. Similar results were reported for niger seed, fababean and pigeon pea by Bhanuwanshe *et al.* (1997) [1] and Shephard and Bharadwaj (1986) [5]. The mathematical models for coefficient of static friction are as under (R^2 = 0.8463, 0.9787, 0.9648 for glass, steel and asbestos respectively).

Glass:

$$K_G = 0.3136 + 0.0085M \quad (14)$$

Steel:

$$K_S = 0.3288 + 0.0106M \quad (15)$$

Asbestos:

$$K_A = 0.43 + 0.0050M \quad (16)$$

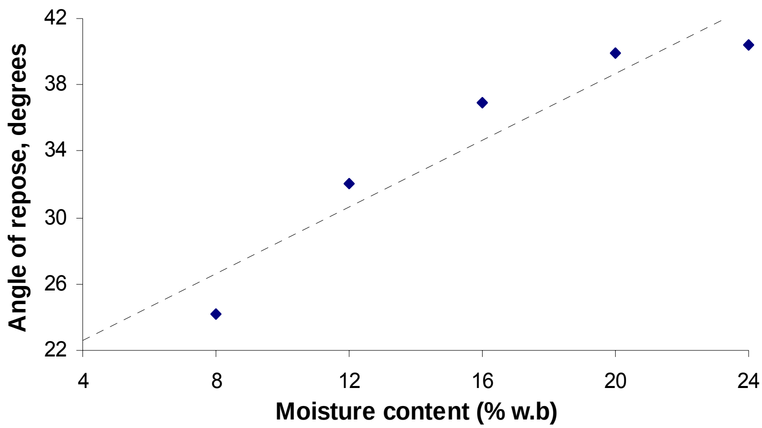

Figure 5. Effect of moisture content on angle of repose

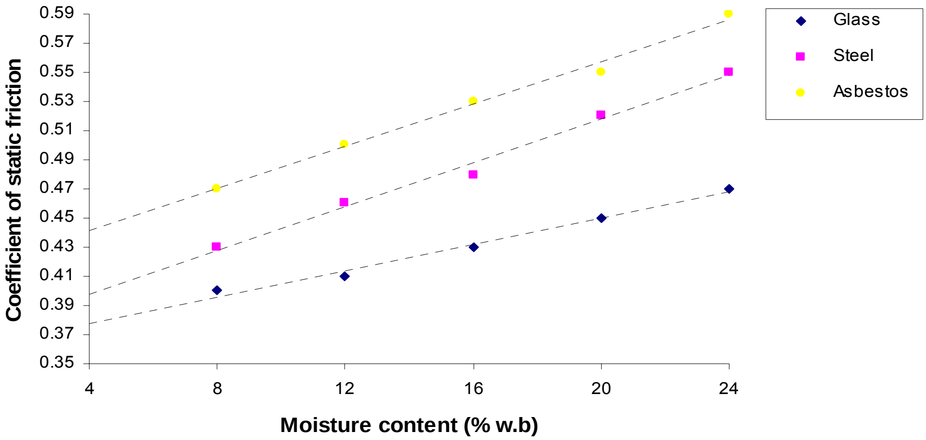

Figure 6. Effect of moisture content on coefficient of static friction

It was revealed that effect of moisture content on gravimetric and frictional properties was found statistically significant at all moisture contents.

CONCLUSIONS

Gravimetric and Frictional properties are the Engineering properties of ridge gourd seed, which are important in the design of storage structures and processing equipments. The gravimetric properties of ridge gourd seed are useful for design and analysis of separation and drying equipments. Frictional properties such as angle of repose and coefficient of static friction are used in the design of storage structure.

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UTICAJ SADRŽAJA VLAGE NA GRAVIMETRIJSKE I FRIKCIONE KARAKTERISTIKE SEMENA TIKVICE (*Luffa Actangula Roxb*)

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Sažetak: Ova studija je izvedena sa pet nivoa vlažnosti (8%, 12%, 16%, 20% i 24%), a proučavani su njihovi uticaji na gravimetrijske i frikcione karakteristike semena tikvice. Gravimetrijska svojstva kao što su masa hiljadu zrna, masa jednog zrna i poroznost linearno su se povećavala sa porastom vlažnosti od 8 do 24 %, izuzev gustine koja je imala trend opadanja. Frikcione osobine, kao što su ugao stabilnosti i koeficijent statičkog trenja takođe su se linearno povećavali sa povećanjem vlažnosti. Masa hiljadu zrna, zapremina jednog zrna grain, gustina i poroznost iznosili su 137.65gm, 0.145cc, 0.666gm·cc^{-1}, 1.124gm·cc^{-1} i 40.75%, redom. Ugao stabilnosti iznosio je 24.16°, a koeficijent statičkog trenja je varirao od 0.40 do 0.47 (zbog različitih površina). Odnos između sadržaja vlage i različitih gravimetrijskih i frikcionih karakteristika takođe je ustanovljen.

Ključne reči*: masa hiljadu zrna, gustina mase, gustina zrna, poroznost, ugao stabilnosti, koeficijent statičkog trenja, sadržaj vlage*

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