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Effect of moisture content on bulk density and angle of repose and co-efficient of friction of faba bean (*Vicia faba* L.)

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ABSTRACT : This study was carried out to evaluate the effect of moisture content on some physical properties of three varieties of faba bean (JV-1, JV-18 and JV- 2). The physical properties of the varieties were determined at four levels of moisture content, including 9, 11, 13 and 15% (w.b.). The results revealed that angle of repose were in the ranges of 0.36 to 0.43 radian. For all of the varieties, by increasing the moisture content the bulk density increased. JV-2 variety of faba bean is best for the designing hoppers, blowers and also for milling than other two varieties.

KEY WORDS : Angle of repose, Bulk density, Faba bean

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Faba bean (*Visia faba* L.) is the first legume crop in Egypt. The cultivated area is 102 thousand hectare with an annual production of 357 thousand tones (FLRP, 2004). The seed forms an important source of protein, with 28% protein content and 58% carbohydrate. Recently, strengthen support for take advantages of the modern biotechnology would be of paramount importance for Egypt to attain self-sufficiency of faba bean crop. Each year, seed developers release many varieties into the market that provide improved productivity and adaptability to adverse conditions. These varieties are nearly similar in their characteristics and different in their properties. Engineering properties of food grains are more important for the post harvest operations. Knowledge of faba bean physical and mechanical properties are very important in the design equipment for handling, drying, aeration, storing structures and processing. Faba bean size and shape varies with variety and seed moisture content. Faba bean is recognized to contribute in solving the malnutrition problem particularly among children in developing countries like India. Faba bean (*Vicia faba* L.) is being introduced as a promising alternative to chickpea (*Cicer arietinum*) both as sourse of food and feed and is commonly used in human and animal diet as a source of protein.

Bulk density is an important physical property that is required to estimate the volume of storage and pressure that act on storage bin walls, separation of desirable materials from impurities, cleaning and grading and quality evaluation of the products (ASAE, 2000a, b, and d). These properties can affect the rate of heat and mass transfer of moisture during aeration and drying processes. The angle of repose is important in designing of storage and transporting structures. Flow ability of rough grains is usually expressed by using the angle of repose (a measure of the internal friction between kernels) that will be useful in hopper design, where the hopper wall's inclination angle should be greater than the angle of repose to ensure the continuous flow of the materials by gravity. A review of literature has revealed that limited research has been conducted on the properties of faba bean. However, detailed measurements of the principal dimensions and the variation of mechanical properties of faba bean varieties at various levels of moisture content have not been investigated. The objective of this study was to investigate moisture-dependent physical and mechanical properties namely bulk density, angle of repose and coefficient of friction of faba bean seed varieties.

METHODOLOGY

Under approximately the same operating conditions, seed size may take a significant role in processing (Subramanian *et al*.,1996) therefore, three faba bean varieties of differing sizes and shapes, faba bean varieties JV-1 (small seeded) JV-18 (medium seeded) and JV- 2 (bold seeded)

were procured from the Department of Plant breeding and Genetics, College of Agriculture, JNKVV, Jabalpur. The seed was cleaned manually to remove foreign matter and broken or immature seed. The clean seeds were sun-dried and the final moisture content of the dried seed was 8.2 % (wet bases).

Faba bean seeds at moisture content of 9, 11, 13 and 15 % were tested. The seed samples of the desired moisture levels were conditioned by adding calculated amounts of distilled water, mixing thoroughly and then sealing in separate polyethylene bags. The samples were kept at 5^0C in a refrigerator for at least a week to enable the moisture to distribute uniformly throughout the sample. Moisture content were measured using the oven method at 103^0C for 72h as described by Fraser *et al*. (1978) and ASAE (2000c). Before starting a test, the required quantity of the seed was taken out of the refrigerator and was allowed to warm up to room temperature. All the physical properties of the seed were assessed at any moisture levels taking 10 replicates. The average ambient temperature was about 24.2^0C.

Physical properties of faba bean seeds:

Bulk density: Bulk density is necessary in design and analysis of separation design of hoppers and blowers, expressed in terms of weight of seed/volume of seed. The bulk density of seed determines the bin volume required storing a certain mass of seed and it increases if the sphericity of the seed is not of uniform size or shape. The greater the size range, the greater the bulk density (Milani *et al*., 2000). The bulk density was determined by filling a circular container of known volume with faba bean seeds and then weighing the cylinder. The ratio of mass to volume gives bulk density.

Mechanical properties of faba bean seeds:

Angle of repose and frictional properties of seeds play an important role in selection of design features of hoppers, chutes, dryers, storage bins and other equipment for seed flow. The angle of repose of the faba bean seeds was determined from the diameter and height of a heap on a circular plate. The seeds were allowed to fall on a circular plate of 200 mm diameter from a height of 15cm so that a natural heap was formed. The height of the heap above a circular plate *H* and the diameter of the heap *D* at its base were measured with the help of a measuring scale and average value of the angle of repose was taken for each moisture contents with different varieties. The angle of repose of the faba bean seed θ was computed calculated as follows: Angle of repose (degree) = Height/ Radius (Jha, 1998).

The statistical analysis:

The analysis of variance and linear regression analysis were employed in this experimental work to study, examine and assess the effect of moisture content changes on the physical and mechanical properties of faba bean seeds.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Bulk density:

The experimental results of the bulk density for faba bean seed at different moisture levels are given in Table 1. Increasing moisture content had a significant effect ($P < 0.01$) on bulk density of faba bean seed by raising it. The bulk density of all the three varieties of faba bean increased from 869, as the moisture content increased from 9 to 15% (d.b.). This was due to the fact that an increase in mass owing to moisture gain in the sample was higher than accompanying volumetric expansion of the bulk (Pradhan *et al*., 2008). The results also showed that JV – 2 variety represented higher bulk density values than the other varieties at all moisture content levels. A similar increasing trend in bulk density has been reported by Baryeh and Mangope (2002) for QP-38 variety of pigeonpea and Kingsly *et al*. (2006) for dried pomegranate seeds and Nimkar and Chattopadhyay (2001) for greengram. They attributed bulk density changes to rearrangement of beans and to bean deformation. They also found that bulk density was directly related to moisture content. Milani *et al*. (2000) indicated that soybean bulk density and kernel density varied with variety and grain moisture content. They found that two soybean varieties had bulk densities of 719 and 721 kg/m^3 at a moisture content of 8.1%. Also, Deshpande *et al*. (1993) found that as moisture content increases, all principal axes of beans expands while bean thickness shows the greatest increase. They also reported that bulk density decreases as moisture content increases due to the expansion of the beans.

Angle of repose:

The angle of repose is an indicator of the product's

Table 1: Effect of different moisture levels on bulk density of various cultivar of *Vicia faba* L.

Treatments	Variety			
Moisture content	JV-1	JV-2	JV-3	Total
9%	2598	2664	2634	7896
11%	2634	2688	2637	7959
13%	2668	2673	2628	7899
15%	2698	2655	2625	7848
Total	10398	10608	10524	31602
SEm (5%) for variety	: 1.88	C.D. for variety	: 5.5	
SEm (5%) for humidity	: 2.17	C.D. for humidity	: 6.36	

Table 2 : Effect of different moisture levels on angle of repose of various cultivar of *Vicia faba* L

Treatments	Variety			
Moisture content	JV-1	JV-2	JV-3	Total
9%	1.08	1.11	1.14	3.33
11%	1.14	1.14	1.17	3.45
13%	1.17	1.0	1.23	3.60
15%	1.23	1.23	1.29	3.75
Total	4.62	1.68	4.83	14.13
SE. (5%) for variety: 0.042	C.D. for variety	: 0.0077		
SE. (5%) for humidity : 0.0042	C.D. for humidity :	0.0087		

ability to flow. The experimental results for the angle of repose with respect to moisture content are shown in Table 2. The angle of repose values were found to increase from 0.36 to 0.43 radian for all the three varieties of the moisture levels (9–15%). This increasing trend of angle of repose with moisture content occurs because surface layer of moisture surrounding the particle hold the aggregate of grain together by the surface tension (Pradhan *et al*., 2008). These results were similar to those reported by Altuntas and Yildiz (2007) and Garnayak *et al*. (2008) for faba bean grains and jatropha seed, Mahmoud Tavakoli *et al*. (2009) also reported similar findings in black gram, green gram and barley.

Conclusion :

It is concluded that as the moisture content of faba bean increased from 9 to 15 %, bulk density and angle of repose increased for all the varieties. JV-2 variety of faba bean best for the designing hoppers, blowers and also for milling than other two varieties.

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