Some Physical Properties of Chick Pea Split (*Cicer arietinum* L.)

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ABSTRACT

Chickpea split of variety PBG-1 was evaluated for their basic physical properties that are often required in order to design production processes, equipment and evaluation of the effect of processing on nutrients, at a moisture content of 12.97 ± 0.30% (dry basis). The average split length, width and thickness dimensions were 6.25, 5.31 and 2.91 mm, respectively. The geometric mean diameter, unit mass, sphericity and true density were 4.58 mm, 0.067 g, 73.46% and 1.202 g/ml respectively. However, static coefficient of friction varied on three different surfaces from 0.30 on galvanized steel sheet, 0.43 on Plywood to 0.45 on glass with splits perpendicular to direction of motion, while the angle of repose was 31.86°.

Keywords: Chickpea, physical properties, sphericity, true density, India.

Nomenclature

L	Length of seed (mm)
W	Width of seed (mm)
T	Thickness of seed (mm)
M	Unit mass
V	Volume
D_e	Geometric mean dimension (mm)
S_p	Sphericity (%)
S_a	Surface area (mm^2)
R_a	Aspect ratio (%)
ρ_b	Bulk density (g/ml)
ρ_t	True density (g/ml)
ε	Porosity (%)
π	Constant (3.142)

1. INTRODUCTION

The chickpea (*Cicer arietinum* L.) is the third most commonly consumed legume in world (Singh, 1988; Singh, 1990). It is also a staple food crop and widely grown in many tropical and subtropical countries. It forms an important source of protein in the Indian vegetarian diet. The chickpeas are a good source of protein and carbohydrate and its protein quality is better than other legumes such as pigeon pea, black gram and green gram. They also supply some minerals (Ca, Mg, Zn, K, Fe, P) and vitamins like thiamine and niacin (Williams & Singh, 1987). India is the premier pulse growing country. The annual chickpea production is about 5.47 million tones and contributes about 65.32% of total production (FAO, 2007). There are two types of chickpea: the small, angular "desi type" and large, rounder "Kabuli type" (Saxena and Singh, 1987). The desi type (kala chana) of chickpea is extensively used for making splits or *dhal* than that of kabuli as former is more economically viable. Thus taking into considerable economic potential of chickpea splits in food and feed industry, it is imperative to determine relevant physical properties of splits.

Fig.1. Pictorial view of Chick pea Splits/dhal

In India chickpea splits are commonly known as "dhal". Dehulled chickpea splits as *chana dhal* (Fig. 1) contains approximately 20.8% protein, 5.6% fat, 2.7% minerals, 1.2% fiber and 59.8% carbohydrate (Gopalan *et al*., 1995).The Chickpea splits are used in vast variety of forms. They may be ground to flour (*besan*), cooked into thick or thin gruels or combined with cereals in diverse way to make traditional foods (*khichdi, dhokla, puran poli*) and used in the preparation of sweet meats (Achaya, 1984)

The physical properties of seeds and splits, like those of other grains and seeds are essential for the design of equipments, especially for handling, processing and storing the grains. Investigations have been made for the physical properties of whole chickpea seeds (Konak *et al.,* 2002). The hydration and swelling properties during soaking of chickpea was studied extensively (Turhan, *et al.,* 2002; Wood & Harden, 2006). The physico-chemical, cooking, textural and roasting characteristics of different chickpea varieties were evaluated by Kaur *et al* (2005). However, no results for the physical properties of chickpea splits yet appear to be available.

The objective of this study was to determine the following physical properties linear dimensions, equivalent diameter, sphericity, aspect ratio, surface area, volume, density, static coefficient of friction against different materials and angle of repose.

2. MATERIALS AND METHODS

2.1 Sample Preparation

The chickpea (*Cicer arietinum*) splits of variety PBG-1 was procured from local dhal mill nearby Sangrur, Punjab. The splits were cleaned in an air classifier to remove lighter foreign matter such as dust, dirt, chaff, immature and broken splits. The initial moisture content of the splits was determined using hot air oven method (Gupta & Das, 2000).

2.2 Physical Characteristics

The shape of the chick pea dhal was found to be a hemisphere with three major perpendicular dimensions, length (L), width (W) and thickness (T). The physical dimensions were determined randomly measuring the length, width and thickness of 100 splits using dial type vernier caliper (Mitutoyo Corporation, Japan) having least count 0.02mm.
The geometric mean dimension (D_e) of splits was found using the relationship given by Mohsenin (1970) as:

$$D_e = (LWT)^{1/3} \qquad (1)$$

The criteria used to describe the shape of the seed are the sphericity and aspect ratio. Thus, the sphericity (S_p) was accordingly computed (Mohsenin, 1970) as:

$$S_P = \frac{(LWT)^{1/3}}{L} \times 100 \qquad (2)$$

The aspect ratio (R_a) was calculated (Maduako & Faborode, 1990) as:

$$R_a = \frac{W}{L} \times 100 \qquad (3)$$

The surface area (S_a) of chickpea splits as semi sphere was calculated using the relationship (Eqn. 4) given by McCabe *et al.* (1986):

$$S_a = \pi D_e^2 \qquad (4)$$

The weights of the splits were recorded using electronic balance (Ishida Co. Ltd., Japan) to an accuracy of 0.001 g. The true density of a split is defined as the ratio of mass of seed to the solid volume occupied (Deshpande *et al.,* 1993). The seed volume and its true density was determined using liquid displacement technique (Shepherd, 1986). Toluene was used in spite of water so as to prevent the absorption during measurement and also to get the benefit of low surface tension of selected solvent (Sitkei, 1986; Ogut, 1998). Seed density was evaluated using the methods suggested by Williams *et al*. (1983). The bulk density is the ratio of mass of a sample of a seed to its total volume. The porosity (ε) of bulk seed was computed from the values of true density (ρ_t) and bulk density (ρ_b) using the relationship (Eqn. 5) given by Mohsenin (1970):

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \tag{5}$$

To determine the angle of repose, a cylinder (50 mm diameter and 60 mm height) was kept vertically on a horizontal galvanized metal floor and filled with the sample. Tapping during filling was done to obtain uniform packing and to minimize the wall effect if any. The tube was slowly raised above the floor so that whole material could slide and form a heap. The height of heap above the floor and the diameter of the heap at its base were measured and the angle of repose (φ) was determined using the relationship (Jha, 1999; Kaleemulah, 1992) as:

$$\varphi = \arctan \frac{(2H)}{D} \tag{6}$$

Where, φ is the angle of repose in degree; H is the heap above the floor in mm and D is the diameter of the heap at its base in mm.
The static coefficient of friction μ was determined for three structural materials namely glass, plywood and galvanized steel sheet. A plastic cylinder of 50 mm diameter and 60 mm height was placed on a adjustable tilting flat plate faced with the test surface and filled with the sample of about 100 g. The cylinder was raised slightly so as not to touch the surface. The structural surface with the cylinder resting on it was inclined gradually, until the cylinder just started to slide down. The angle of tilt was noted from a graduated scale (Dutta *et al.,* 1988; Fraser et al., 1978; Shefered & Bhardwaj, 1986).
All the above experiments were replicated as indicated in Table 1 and the average values were reported.

3. RESULTS AND DISCUSSION

A summary of the results for all parameters measured and determined is shown in Table 1. The frequency distributions of the physical properties are shown in Fig. 2. The moisture content of the splits at the time of experiment was 12.97 ± 0.30% dry basis. The moisture content found can help to suggest the stability in storage of splits, as higher the moisture content more the risk of spoilage of food material.
Length (L) for the splits ranged from 5.4 to 6.9 mm with the mean value as 6.25 ± 0.40 mm (Table 1). However, a greater percentage (58%) of the seed longitudinal dimension lies between 6.0 and 6.6 mm with 31% between 6.3 and 6.6 mm. For the width (W), the distribution was 40% and 24% between 5.18–5.42 and 4.94–5.18 mm, respectively. A similar trend was observed for the seed thickness (T) as 47% and 20% for 2.66–2.92, 3.18–3.44 mm, respectively. Although, Mohsenin (1970) had effectively highlighted the imperativeness of the axial dimensions in machine design, the comparison of the data with existing work on the

other seeds can be sufficient in making symmetrical projections towards process equipment adaptation.

It is seen from Table 1 that the sphericity and aspect ratio of the split varied from 66.13 to 83.11 (±3.995) %, 73.91 to 100 (±6.414) %, respectively. Within the ranges, 67% of the aspect ratio is from 79-91% with 32% of the value having a range of 85-91%. The sphericity data also indicates 38% of the data between 73.0-76.5% and 30% between 69.5-73.0% (Fig. 2; Table 1). The high sphericity value thus suggests that the splits tend towards a hemispherical shape (Omobuwajo *et al.,* 2000) being semi spherical. Thus the values of the aspect ratio and sphericity generally indicate a likely difficulty in getting the splits to roll. They can, however, slide on their flat surfaces. This tendency to either roll or slide should be necessary in the design of hoppers for milling process. However, the surface area ranged from 51.13 to 82.4 (±6.848) mm^2, respectively. The surface area is a relevant tool in determining the shape of the seeds. This will actually be an indication of the way the splits will behave on oscillating surfaces during processing (Alonge & Adigun, 1999).

The average split weight was 0.067 g, although the weight varied between 0.059 and 0.079 (±0.005) g. The weight of food grains is an important parameter to be used in the design of cleaning grains using aerodynamic forces (Oje & Ugbor, 1991). It is observed that about 62% of unit split mass was ranged between 0.059-0.067 gm. The true density value lies within 1.128 to 1.160 g/ml. However; the mean value was 1.202±0.057g/ml. The volume of splits ranged from 0.052 to 0.057ml with mean value of 0.055±0.002ml. The porosity of the splits was found to be 40.70 ± 0.905%.

The frictional properties examined for the splits are the angle of repose and the coefficient of static friction. Essentially, the angle of repose was 31.86 ± 0.573^0. This phenomenon is imperative in the food grain processing, particularly in the designing of the hopper for milling equipment.

The coefficient of static friction for chickpea splits was determined with respect to glass, plywood and galvanized steel sheet. The co-efficient of static friction found was 0.452 on glass, 0.428 on plywood and 0.302 on galvanized steel sheet. At the 12.97 ± 0.30% moisture content, the static coefficient of friction was highest for glass.

Table 1: Some physical properties of Chick pea splits

Physical Properties	No. of observations	Unit of measurement	Mean Value	Min value	Max value	Standard Deviation
Length	100	mm	6.250	5.40	6.90	0.399
Width	100	mm	5.310	4.70	5.90	0.317
Thickness	100	mm	2.910	2.40	3.70	0.295
Geometric mean dimension	100	mm	4.580	4.03	5.12	0.238
Surface area	100	mm^2	66.110	51.13	82.40	6.848
Volume	10	cm^3	0.055	0.052	0.057	0.002
Unit mass	10	g	0.067	0.059	0.079	0.005
True density	10	g/ml	1.202	1.128	1.260	0.057
Bulk density	10	g/ml	0.713	0.68	0.76	0.032
Porosity	10	%	40.695	39.85	42.86	0.905
Spherecity	100	%	73.460	66.13	83.11	3.995
Aspect ratio	100	%	85.270	73.91	100.00	6.414
Mass of 1000 kernel	100	g	69.520	63.45	79.56	6.837
Angle of repose	5	degrees	31.860	30.97	32.45	0.573
Coefficient of static friction for glass	5	--	0.452	0.44	0.46	0.008
Coefficient of static friction for plywood	5	--	0.428	0.42	0.44	0.007
Coefficient of static friction for galvanized steel	5		0.302	0.29	0.31	0.009

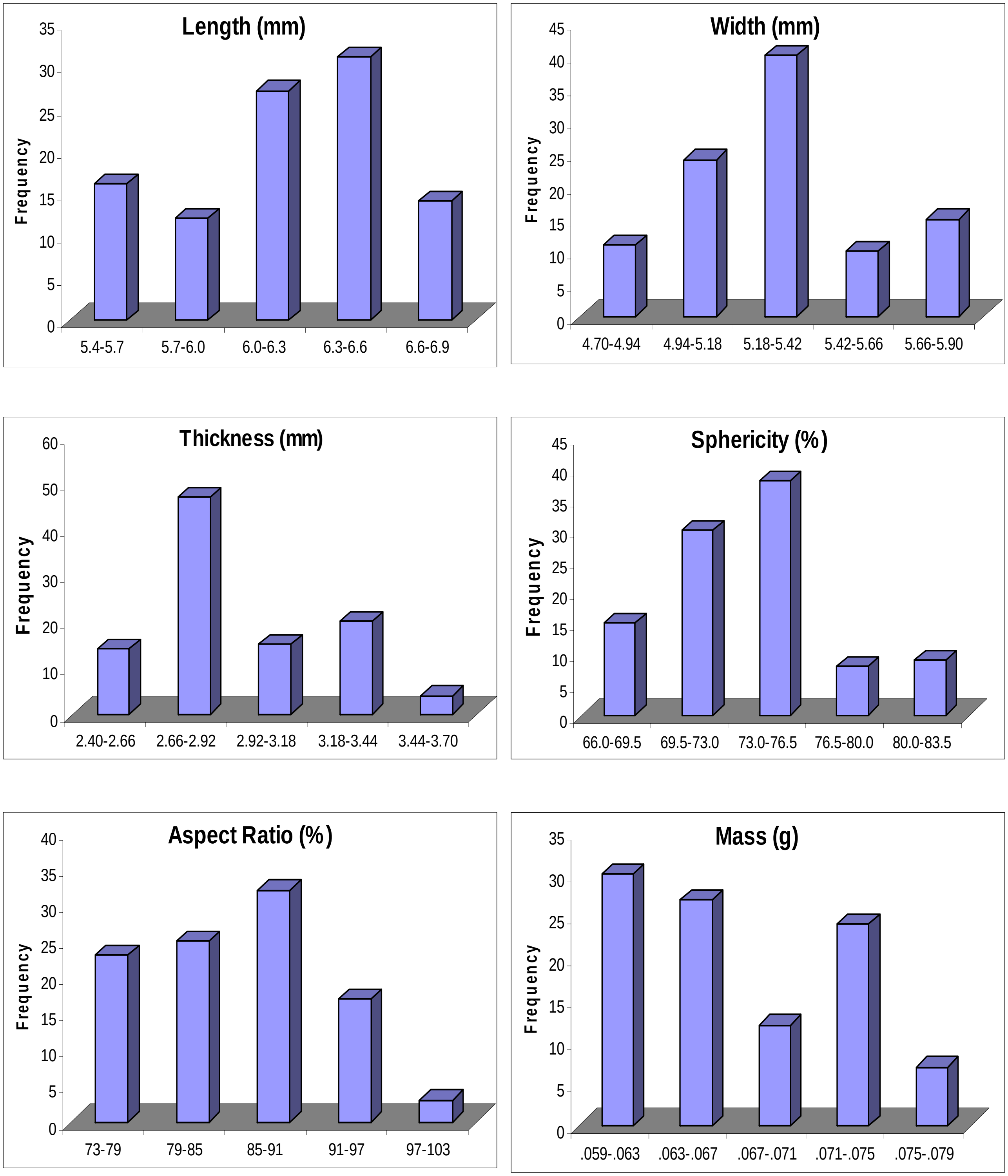

Fig.2. Frequency distribution of selected physical properties of Chick pea splits.

4. CONCLUSIONS

1. The average values of physical properties of chickpea splits length, width, thickness, unit mass and volume measured at a moisture content of 12.97 ± 0.30% (dry basis) were 6.25 mm, 5.31 mm, 2.91 mm, 0.067 g, and 0.055 cm^3 respectively.
2. The calculated physical properties like geometric mean diameter, surface area, porosity, sphericity, true density, aspect ratio were 4.58 mm, 66.110 mm^2, 40.695 %, 73.46%, 1.202 g/ml, 85.27 % respectively.
3. The static coefficient of friction varied on three different surfaces from 0.30 on galvanized steel sheet, 0.43 on Plywood to 0.45 on glass with splits perpendicular to direction of motion, while the angle of repose was 31.86°.
4. The physical parameters L, W, T were having positive skew ness.
5. All standard deviation of all the measured parameters ranged between 0.01 and 7.00 showing near uniform dispersion about their respective mean values.

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