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Studies on Some Physical Properties of Protein-rich Legume (*Lens esculantus*) Splits

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Basic physical properties of biomaterials that are often required in order to design production equipment, processes and assessment of the effect of processing on nutrients were determined for an important legume *Lens esculantus* splits, at a moisture content of 10.06± 0.59 % on dry weight basis. The average longitudinal, transverse and thickness dimensions were 3.67, 3.46 and 0.47 mm, respectively. The geometric mean diameter, sphericity, aspect ratio and true density were 1.79 mm, 49.69 %, 94.36 % and 3.35 g/ml, respectively. However, static coefficient of friction varied on two different surfaces from 0.191 on glass to 0.469 on galvanized steel sheet with the legumes perpendicular to the direction of motion, while the angle of repose was 31.89º. The optical parameters were evaluated using hunter color technique on L, a & b scale and found 61.078, 27.756 and 27.524, respectively confirming the characteristic color of selected biomaterial.

Key Words: Biomaterial, Lens esculantus, color, physical properties

INTRODUCTION

Whole pulse seeds have been stripped of their outer hulls to yield splits. Though whole pulses have a good nutritional value but hulling of the pulses improves the digestibility and palatability[1]. The word lentil (*Lens esculantus*) is derived from its lens-shaped seeds. This plant has been originated in Near-East. India leads the world in lentil production. Being leguminous plants they are rich in protein (28.06%). Lentils are high in carbohydrates, vitamins which include B vitamins, especially B_3, which is essential for both a healthy nervous system and digestive system. They are high in iron, zinc and calcium and considered as replacement for red meat. Like meat, the iron in lentils is better absorbed when they are consumed with vitamin C rich preparations like leafy vegetables[1].

The physical properties of legumes are very significant for the design of equipments, especially for handling, processing and storing the grains. Investigations have been made for the physical properties of chickpea splits[2]. The physico-chemical, cooking, textural and roasting characteristics of whole grains were evaluated in past. However, no results have been seen for the studies of physical properties of *Lens esculantus* splits. The objective of the present study was to portray the protein-rich biomaterial (*Lens esculantus*) splits on the basis of physical properties, mainly the dimensional, gravimetric, frictional and optical properties so as to asses the suitability of this important functional biomaterial for quality characterization through image analysis.

EXPERIMENTAL

The split pulses were procured from local dhal mill available 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[2].

Physical Characteristics

The linear dimensions of the pulses were measured by using three major perpendicular dimensions, length (L), width (W) and thickness (T). The physical dimensions were randomly measured for 100 pulse splits using dial type vernier caliper (Mitutoyo Corporation, Japan) having least count 0.02 mm. The geometric mean dimension (D_e) of splits was found using the relationship[2]:

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

The criteria used to describe the shape of the seed are the sphericity and aspect ratio. Thus, the sphericity (S_p) was accordingly computed[2]:

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

The aspect ratio (R_a) was calculated as[2]:

$$R_a = \frac{W}{L} \times 100 \tag{3}$$

The surface area (S_a) of splits were calculated using the relationship[2]:

$$S_a = \pi D_e^{\ 2} \tag{4}$$

The weights of the splits were recorded using electronic balance (Ishida Co. Ltd., Japan) to an accuracy of 0.001 g. The porosity (ε) of bulk seed was computed from the values of true density (ρ_t) and bulk density (ρ_b) using the relationship:

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

The angle of repose (φ) was determined using the relationship:

$$\varphi = \text{arc tan}\frac{(2H)}{D} \tag{6}$$

Where, H and D are the height and diameter of the heap in mm. The static coefficient of friction μ was determined for two structural materials namely glass and galvanized steel sheet. A plastic cylinder of 50 mm diameter and 60 mm height was placed on an adjustable tilting flat plate faced with the test surface and filled with the sample of about 100 g. The cylinder was raised slightly to avoid touching the surface. The structural surface with the cylinder resting on it was inclined gradually, until the cylinder just started to slide down.

There are different techniques to determine the optical parameters of a biomaterial, one of which includes Hunter color system. In present case, the values are in L, a & b form. Here, the white point is at the origin with hunter positive a value indicating redness and negative a values indicating greenness. On the other hand, the hunter positive b value indicates yellowness and negative b values blueness, whereas, L here refers to as visual lightness in perceptibility units. All the above experiments were replicated and reported as average values.

RESULTS AND DISCUSSIONS

A summary of the results for the parameters are shown in Table 1 with radar representations in Fig.1. The moisture content of the splits was 10.06 ± 0.59 % on dry weight basis. The moisture content appraised can help to suggest the stability in storage of splits, risk of spoilage is higher at higher moisture levels. The longitudinal dimension (L) for the splits ranged as 4.19 ± 0.05 mm (Table 1). For the transverse dimension (W), the values were in the range of 3.91± 0.06 mm, whereas, thickness lies in the range of 0.47 ± 0.24 mm. 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 is effectively highlighted[3].

The geometric mean dimension (D_e) are highlighted in Table 1. The values of D_e ranged from 1.52 to 2.24 mm The Geometric Mean Dimension is important in itself as it is related with the three major dimensions of the split (L, W and T). The sphericity and aspect ratio of this protein-rich legume split lies in the range of 36.76 to 53.33% and 92.38 to 93.65 %, respectively (Table 1). The high sphericity value indicates that the legume split is inclining more towards hemispherical shape being semi spherical[4]. Hence, the values of the aspect ratio and sphericity indicate a difficulty in roll. This tendency to either roll or slide should be necessary in the design of hoppers for milling process.

It is seen from Table 1, the different values of surface area which lies in the range of 7.28 to 15.26 mm^2. It is studied that this will actually be an indication of the way the splits will behave on oscillating surfaces during processing[5].

TABLE 1
SOME PHYSICAL CHARACTERISTICS OF *LENS ESCULANTUS* SPLITS

Physical Properties	Replicates	Units	Mean value	Minimum value	Maximum value	Standard deviation
Length	100	mm	4.19	4.14	4.25	0.05
Width	100	mm	3.91	3.87	3.98	0.06
Thickness	100	mm	0.47	0.22	0.69	0.24
Geometric mean	100	mm	1.94	1.52	2.24	0.37
Surface area	100	mm^2	12.08	7.28	15.26	4.35
Volume	10	mm^3	7.79	3.53	11.24	3.93
True density	10	g/ml	5.027	5.024	5.030	0.003
Bulk density	10	g/ml	0.836	0.826	0.844	0.009
Porosity	10	%	83.37	83.23	83.56	0.17
Sphericity	100	%	46.12	36.76	53.33	8.49
Aspect ratio	100	%	93.17	92.38	93.65	0.68
Mass of 1000 kernel	100	g	13.15	12.87	13.45	0.29
Angle of repose	5	degree	30.96	30.02	31.89	0.94
Coefficient of static friction						
Glass	5	_	0.186	0.181	0.191	0.005
Galvanized steel sheet	5	_	0.464	0.459	0.469	0.005

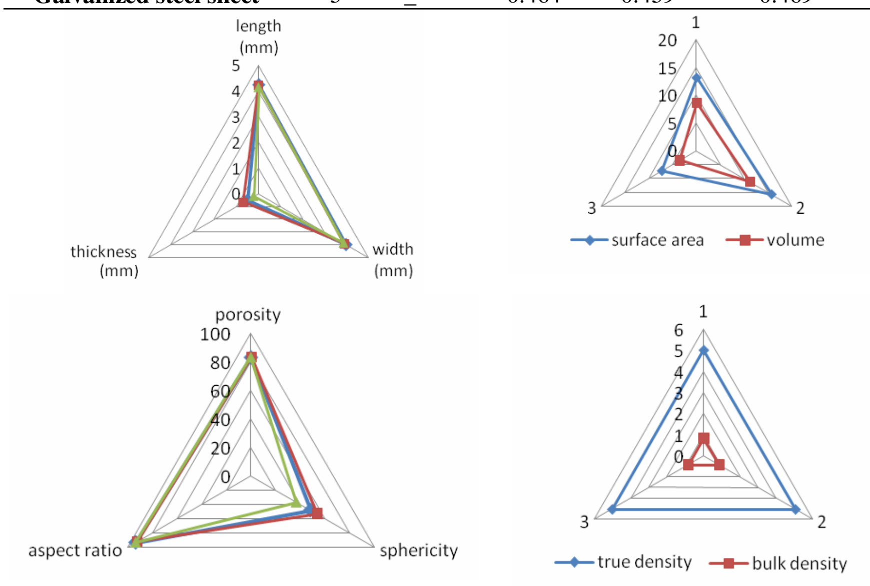

Fig. 1: Radar representations of selected physical characteristics

The true density and bulk density lies in the range of 5.024 to 5.030 g/ml and 0.826 to 0.844 g/ml, respectively. The porosity which is in relation to true density and bulk density (Eqn. 5) lies within 83.23 to 83.56 %. The volume of the leguminous split is in the range of 3.53 to 11.24 mm^3 (Fig. 1).

The frictional properties determined for this leguminous split are the angle of repose and the coefficient of static friction. From Table 1 it is observed that the values of angle of repose lies in the range of 30.02 to 31.89º. This phenomenon is imperative in the food grain processing, particularly in the designing of the hopper for milling equipment. The coefficient of static friction found as 0.186 ± 0.005 for glass and 0.464 ± 0.005 for galvanized steel sheet. This concept has been tried to be made clear in the radar diagrams (Fig. 1).

The optical parameters of these splits were determined using hunter color technique on L, a & b scale and found values as 61.078, 27.756 and 27.524, respectively, which has confirmed the characteristic colour property of the selected biomaterial under investigation.

Conclusions

Lens esculantus split is an important protein rich biomaterial particularly used as major item of staple food in Indian cuisine. In addition, it is an essential ingredient in the production of some specialty food preparations. The following conclusions are drawn from the investigation on physical properties of *Lens esculantus* splits that Tte high sphericity value indicates this legume split is inclining more towards hemispherical shape and affect adversely the splits to roll. The static coefficient of friction is surface specific with less angle of repose as compared to other legume splits. The lentil splits were observed to be light reddish orange in color and characterizing this pulse split. The uniformity of linear dimensions and colour make this pulse split a suitable biomaterial for quality assessment through image analysis.

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