Research Inventy: International Journal Of Engineering And Science
Vol.2, Issue 8 (March 2013), Pp 23-27
Issn(e): 2278-4721, Issn(p):2319-6483, Www.Researchinventy.Com

Moisture Dependant Physical Properties of Sunflower Seed (Psh 569)

SURESH BHISE[1], KAUR A[2] AND MANIKANTAN M R[3]
[1,2]*Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, Punjab, India.*
[3]*Food Grains and Oilseed Processing Division, CIPHET, Ludhiana, Punjab, India.*

Abstract: *Physical properties of sunflower seeds were evaluated as a function of moisture content. Various physical properties of seeds and their fractions are dependent on moisture content and appear to be important in the design of handling and processing equipment. The geometric mean diameter and sphericity of the seed were 6.69 mm and 0.63 respectively. In the moisture range from 10-18% w.b., the bulk density of the rewetted seed decreased from 330.7 to 320.88 kg/m^3, true density increased from 688.10 to 725.56 kg/m^3, thousand kernel weight (TKW) increased from 75.31 to 78.86 g and porosity increased from 51.94 to 55.77 %. In the same moisture range the static coefficient of friction varied from 0.51 to 0.61 for seed different surfaces, while the angle of repose varied from 18.10 to 24.07 for seed. Hardness and initial cracking force for sunflower seed decreased with increase in moisture content.*

Key Words: *Moisture, Physical property, Porosity, Sunflower.*

I. INTRODUCTION

Sunflower (*Helianthus annuus L*) is one of the world's leading oilseed crops, second only to soybean for total oil production. Some physical properties of this seed and comparison with other seeds are considered to be necessary for the proper design of equipment for handling, conveying, separation, dehulling, drying, mechanical expression of oil, storage and other processes (Kachru *et al* 1993). Despite an extensive search, no published literature was found on the detailed physical properties of sunflower seed and their dependency on operational parameters which would be useful for the design of dehulling and storage systems. The properties of different types of grains and seeds have been determined by other researchers such as Ougt (1998) for white Lupin; Baryeh (2002) for millet; Cetin (2007) for barbunia bean; Ogunjimi et al. (2002) for locust bean seed and Coskun et al. (2006) for sweet corn seed. Bulk density, true density and porosity can be useful in sizing grain hoppers and storage facilities. They can affect the rate of heat and mass transfer of moisture during aeration and drying processes. Grain bed with low porosity will have greater resistance to water vapor escape during the drying process, which may lead to higher power to drive the aeration fans. The static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. Such information is useful in sizing motor requirements for grain transportation and handling (Ghasemi Varnamkhasti et al 2007).

In this study, some physical properties of sunflower seed were determined, namely, size and shape, bulk and true densities, porosity, static coefficient of friction against the different material surfaces and angle of repose at various moisture contents in the range of 10-18% w.b. Although moisture content has been reported to influence several physical properties, Gupta and Prakash (1992) reported non-significant variations of sphericity for a wide range of moisture contents in safflower seed. An increase in seed moisture content was found to increase the angle of repose in fababean (Fraser *et al* 1978) as well as the coefficient of static friction in safflower seeds (Gupta and Prakash 1992). In this study, some physical properties were investigated, namely, size and shape, densities, coefficient of static friction against different material surfaces, thousand kernel weight and angle of repose of sunflower seed at various moisture contents ranging between 10-18% w.b.

II. Material And Methods

For this study, the short duration variety of sunflower *PSH 569* maturing within 90-100 d and widely grown in Punjab, India was selected. Six bulk samples each consisting of 5 kg of seeds was procured from the Punjab Agricultural University, Ludhiana during July 2012. Seeds were packed in double layered low density polyethylene bags and stored at low temperature (4±1^{o}C). The method of random sampling was used for sample preparation (Dutta *et al* 1988). For each individual seed three principal dimensions namely length, width and thickness were measured using a digital vernier caliper (accuracy 0.1 mm). To obtain the mass, each seeds were weighed on a precision electronic balance reading to 0.0001 g.

2.1 Moisture content

The samples of the desired moisture contents were prepared by adding required the amount of distilled water as calculated from the following relation (Sacilik et al 2003).

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

Where W_i, is the initial mass of the sample in kg; M_i, is the initial moisture content of the sample in % w.b.; and M_f, is the final moisture content of sample in % w.b. Before starting a test, the required quantity of the seeds were taken out of the refrigerator and allowed to equilibrate to the room temperature for about 2 h (Singh and Goswami, 1996). All the physical properties of the seeds were determined at five moisture contents (10%, 12%, 14%, 16% and 18%) with 15 replications at each moisture contents. The moisture content of seed was determined by an oven drying method (ISI 1966).

2.2 Geometric mean diameter and sphericity

The geometric mean diameter (GMD) and sphericity (Ø) of seeds were determined using the following expressions.

$$GMD = (LWT)^{1/3} \quad (2)$$

$$\text{Sphericity} = \frac{(LWT)^{1/3}}{L} \quad (3)$$

Where L, W and T are length, width and thickness respectively .

2.3 Bulk density and true density

The bulk and true density for both seed at different moisture levels were determined. The bulk density (ρ_b) is the ratio of the mass sample of the grain to its total volume. It was determined by filling a 1000 ml container with grain from a height of 15 cm, striking the top level and then weighing the contents (Mohsenin 1970). Bulk density for each replication was calculated from the following relation:

$$\rho_b = \frac{W_s}{V_s} \quad (4)$$

Where: the ρ_b is the bulk density in kg/m^3; *Ws* is the weight of the sample in kg; and V_s is the volume occupied by the sample in m^3.The true density ((ρ_t) was defined as the ratio between the mass of Sunflower seeds and the true volume of the seeds, and was determined using the toluene (C_7H_8) displacement method. Toluene was used instead of water because it is absorbed by seeds to a lesser extent. The volume of toluene displaced was found by immersing a weighted quantity of fennel seeds in the measured toluene (Tavakkoli et al 2009).

2.4 Porosity

The porosity was calculated from the values of bulk and true densities using the following relationship (Mohsenin 1970)

$$\text{Porosity} = \frac{(\text{True density} - \text{Bulk density}) \times 100}{\text{True density}} \quad (5)$$

2.5 Angle of repose

The emptying or dynamic angle of repose was measured for five moisture contents. For such measurement, a plywood box with a removable front panel was filled with grains. The front panel was quickly removed, allowing the seeds to flow and assume a natural slope (Dutta *et al.* 1988). The angle of repose was calculated from the measurements of the vertical depth and radius of spread of the sample.

2.6 Static coefficient of friction

The static coefficient of friction for seed was measured against two structural materials, namely mild steel and galvanized iron. A galvanized iron cylinder of 100 mm diameter and 50 mm height was placed on an adjustable tilting plate, faced with the test surface, and filled with the sample. The cylinder was raised slightly so as not to touch the surface. The structural surface with the box resting on it was inclined gradually with a screw device until the box just started to slide down and the angle of tilt was read from a graduated scale (Joshi et al 1993). All the experiments were carried out three times, unless stated otherwise, and the average values reported.

2.7 Texture analysis

Texture of the sunflower was evaluated on texture analyzer (TA-XT2i) (Bourne 1982). Sunflower subjected to compression test to measure hardness (N), initial cracking force (N) and area (Nmm) at different moisture content.

2.8 Color analysis

Colour value L, a, b and hue angle were measured using Hunter Lab Colorimeter (Kimura *et al.,* 1993) of sunflower.

III. Results And Discussion

3.1. Geometric mean diameter and sphericity

The geometric mean diameter of sunflower seed (Table 1) was higher than those reported for pigeonpea, muskmelon and longmelon seed (Ramakrishana 1986) and was found close to safflower. Sphericity of sunflower seed was much lower than those reported for pigeonpea (Shepherd and Bhardwaj 1986).

3.2. Thousand kernel weight

The thousand kernel weight of seeds was measured in the moisture range between 10 and 18% w.b. (Table 1). The thousand kernel weight increased with the increase in moisture content for seed. It increases from 75.31g to 78.86 g. The results showed that the mass of 1000 seeds was close to lentils (Makanjuola 1972) but larger than millet (Baryeh 2002) and karingda seeds (Suthar and Das 1996).

3.3. Bulk density

The bulk density of seeds was measured in the moisture range between 10 and 18% w.b. The bulk density decreased with the increase in moisture content for seed (Table 1). Thus, it appears that the increase in volume was more than proportional to the increase in mass of the bulk seed. The bulk density of sunflower seed was compared with those of other grains and it was observed that the bulk density of seed at a given moisture level was lower than those of safflower (Gupta and Prakash 1992).

3.4. True density

The true density of seed was found to vary from 688.10-725.56 kg/m^3, when the moisture level increases from about 10 to 18% w.b. (Table 1). Graph show that the true density of seeds varies linearly with moisture content similar to other grains such as corn and hard red winter wheat. The true density of sunflower seeds was found to be less than that of safflower (Gupta and Prakash 1992) and pumpkin seeds (Joshi et al 1993).

3.5. Porosity

The porosity was evaluated for sunflower seeds using Eqn 5. It increased from 51.94 to 55.77% for seeds when the moisture content changed from 10 to 18% w.b. (Table 1). Higher porosity provides better aeration and water vapor diffusion during deep bed drying. Similar trend was reported for hazel nuts (Aydin, 2002) gram (Dutta et al 1988), sunflower (Gupta and Das 1997).

3.6. Static coefficient of friction

The experimental results showing the effect of moisture content and structural surfaces on the static coefficient of friction are given in Table 1. for seed, friction increased with moisture content against both mild steel and galvanized iron. Further, these values were slightly higher for mild steel than for galvanized iron. This may be due to the smoother surface of galvanized iron compared with mild steel. The difference in coefficients for seed on both the surfaces was found to be significant at the 1% level at moisture contents between 10 and 18% w.b. Similar findings were reported for millet (Baryeh 2002), pumpkin seeds (Joshi et al 1993), and karingda seeds (Suthar and Das 1996), corn seed (Seifi and Alimardani 2010)

3.7. Angle of repose

The angle of repose of sunflower seed at different moisture contents are shown in Table 1. It increased from 18.10 to 24.07 for seed in the moisture range of 10 to 18% w.b. This may be due to the rough surface or shape factor of sunflower seed that imposes resistance to the seeds in sliding on one another. The surfaces of the pigeonpea, fababean, safflower and oilbean seed may be comparatively smoother or have a greater sphericity thus enabling them to slide more easily on one another, resulting in a lower value of angle of repose. A linear increasing angle of repose as the seed moisture content increases has also been noted by Chandrasekar and Viswanathan (1999) for coffee, Oje and Ugbor (1991) for oilbean seeds, Joshi et al (1993) for pumpkin seeds.

3.8. Hardness and initial cracking force

The hardness and initial cracking force of sunflower seed at different moisture contents are shown in Table 1. Both hardness and initial cracking force decreased from 98.63 to 35.92 N and 36.18 to 19.34 respectively, for seed in the moisture range of 10 to 18% w.b. With increase in moisture content both hardness and initial cracking force decreased. A linear decreasing in hardness and initial cracking force as the sunflower seed moisture content increased has been observed.

3.9. Color

The color sunflower seed at different moisture contents are shown in Table 1. L, a, b and z% value were measured at different moisture content. A linear increasing in L, a and b value as the sunflower seed moisture content increases has been reported but similar finding was not in literature.

IV. Conclusions

The mean geometric mean diameter and sphericity of seed were 6.69 mm and 0.63 respectively. The For the seed, bulk density decreased from 330.70 to 320.88 kg/m^3 while true density increased from 688.10 to 725.56 kg/ m^3 as the moisture content increased from about 10-18% w.b. The static coefficient of friction of seed was lower and varied from 0.512 to 0.612 for seed with increase in moisture content from 10- 18% w.b. The friction coefficient values were higher on mild steel than on galvanized iron surfaces at all moisture levels. The angle of repose increased from 18.10 to 24.07 for seed in the moisture range of 10-18% w.b. Various physical properties of seeds and their fractions are dependent on moisture content and appear to be important in the design of handling and processing equipment.

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Table 1. Variation in physical property of sunflower seed at different moisture content

Seed dimension	**Moisture content (%)**									
	10		12		14		16		18	
	Mean*	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
Length (mm)	10.442	0.5128	11.473	3.2587	11.191	1.1145	11.461	1.0648	11.698	0.9836
Width (mm)	6.307	0.498	5.951	0.6163	6.424	0.7063	6.614	0.37	6.741	0.5691
Thickness (mm)	3.896	0.5928	4.004	0.655	4.248	0.7673	4.463	0.4217	4.403	0.4509
GMD	6.354	0.4549	6.49	0.6007	6.7342	0.5094	6.9679	0.3352	7.01402	0.418
Sphericity	0.59959	0.2275	0.5694	0.3004	0.59883	0.2547	0.6068	0.1676	0.5584	0.209
TKW	75.3147	1.8905	76.992	2.462	77.1587	2.5995	78.615	1.8783	78.86	4.6817
Bulk density	330.7	0.011	318.19	0.0087	314.702	0.0134	316.3	0.0134	320.882	0.0138
True density	688.104	0.0252	687.42	0.0232	693.572	0.0646	696.07	0.0394	725.564	0.0423
Porosity	51.9403	0.367	53.712	0.764	54.6258	0.893	54.56	0.662	55.7748	0.845
Angle of repose	18.103	1.2453	20.312	0.7356	22.3516	0.9776	22.831	0.6639	24.0772	0.7839
Coefficient friction	0.512	0.023	0.533	0.014	0.578	0.07	0.6	0.032	0.612	0.042
Hardness (N)	98.6304	10.035	84.793	2.726	48.1436	5.1101	36.283	7.9799	35.9222	4.3109
Initial cracking force (N)	36.1752	5.3012	32.708	2.3395	24.2158	5.2489	21.71	6.4411	19.3374	5.0582
Area (Nmm)	45.46	3.6662	33.4	5.4377	20.1736	1.9302	18.064	2.5747	11.2784	3.8264
Color L	39.62	2.53	40.78	3.68	45.39	3.18	46.33	2.1065	48.7725	1.8615
a	0.17	0.59	-0.05	0.23	-0.53	0.92	0.1975	0.5003	0.2375	0.5039
b	0.2	0.97	0.51	0.84	1.15	1.79	1.5775	0.6354	1.8075	0.9043
z%	10.97	1.49	14.2	2.85	14.35	1.57	14.43	0.9681	15.445	0.9795

* each value is mean of three replication

SD- standard deviation