Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 20, Issue 3, 2020
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MONITORING WHITE MOLD *SCLEROTIA PERORATES* TO REDUCE THE RISKS IMPACT ON IMPORTED SOYBEAN SEEDS

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Abstract

The dissimilarity in the engineering characteristics of white mold which leads a difficulty in soybean seeds separating , this difference in the engineering characteristics of the white mold constructions differ according to the degree of infection and the period of storage, which results in irregularly from wide range in shaped white mold constructions which leads to the separation efficiency decreases and repetition of the separation processes. The aim of the study is to decide the engineering properties of American soybean seeds and white mold (Sclerotinia sclerotiorum) imported from the USA to Egypt. The experimental work was carried out until 2018 in the Agricultural Engineering Department, Faculty of Agriculture, Tanta University, Egypt. The engineering properties can be used in the design and development of handling, transportation, storage and separation equipment. Seed dimensions were tested at moisture levels between 8.85 and 12.30% (wet basis). The results showed that by changing the moisture content the average dimensions of the soybean seeds were changed, respectively, from 5.39 mm to 5.96 mm, and the width from 4.76 mm to 5.16 mm. Thickness changes from 3.98mm to 4.38mm. The size is 55.8 to 71.93mm3, the average geometric diameter is from 4.66 to 5.05mm. Arithmetic average diameter from 4.7 to 5.10 mm. Sphericity decreased from 86.94 to 85.10%. Also, the surface area changed from 68.29 to 80.17 mm 2. On the other hand, the dimensions of the hardening of the white mold ranged according to the place imported, with the length ranging from 5.85 to 20.31 mm, the width from 1.32 to 4.39 mm, the thickness from 0.88 to 3.07 mm, and the size from 9.75 to 75.19 mm3, the mean geometric diameter from 2.64 to 5.22 mm, the arithmetic mean of diameter from 3.02 to 8.07 mm and spherical diameter from 15.98 to 58.81%. Also, the surface ranged from 22 to 85.85 mm 2. These results showed that the difference between the physical properties of soybeans and white rot is not strong in terms of length, width and thickness in this case, which impedes the separation processes.

Key words: *soybean, physical and chemical properties, white mold, sclerotia, moisture content*

INTRODUCTION

Egypt imported about 3,045,469.31 tons from USA according to Minstry of agriculture statics in 2018. Soybean white mold named because the fungal disease produces a white fluffy cottony growth in the outside of the stem and on the poods. *Sclerotinia sclerotiorum* lives in the soil as sclerotia, which were hard, black structures, it is the major soybean disease in the Upper Midwest region of the United States and southern Canada which causes loss in soybean yield by reducing weight and seed number during the reproductive growth stage. It can be observed in harvested grain which affected in seed quality and seed production.

Soybean is one of the most important member from the Fabaceae family. The total production of soybean in the world is 352.6 million tonnes. On the other hand, Egypt production of soybean in 2017 was 45,000 tons according to FAO (2017) Soybean (*glycin max*) has a relatively high protein content (35–42%) and oil (16–27%). This makes the soybean be the most valuable and commonly cultivated crop [5].

The physical, mechanical and aerodynamic properties of agricultural products must be determined to use in design of the different component of machines and equipment for cleaning processes, handling, transporting and storage [1], [4], [9] and [11].

The moisture content of soybean seeds ranging from 6.92 to 21.19 % d.b. to evaluate the effect of moisture content on some physical properties. As the moisture content increased from 6.92% to 21.19% d.b. where the bulk density and true density were found to decrease from 650.95 to 625.36 kg/m^3 and from 1,147.86 to 1,126.43 kg/m^3 respectively, while the porosity was found to increase from 43.29% to 44.48% [8].

The physical properties of soybean at various moisture levels. The geometric mean diameter increased from 5.44 to 5.57 mm and the sphericity varied between 0.83 and 0.84 as moisture content increased from 7.37% to 15.80% (db), respectively. At moisture content of 7.37% (dry basis) the average of length were 6.55 mm, width were 5.56 mm, thickness were 4.53 mm and thousand mass, were 103.57 g, [10].

The seed dimension, geometric mean diameter, individual seed weight, sphericity, thousand seed, weight, bulk and true density, porosity angle of repose and static coefficient were effected by moisture content. Moisture contents of soybean seeds were determined as 7.95, 13.68 and 19.14% (dry basis) [7].

One of the greatest problems faced the development of soybean diseases because this can trigger significant losses in relation to yields and increased production costs of the grain and seeds, mainly due to the utilization of agrichemicals in crop fields. However, in order to occur epidemics caused by such a pathogen it is necessary that the climatic conditions, mainly air temperature and relative humidity be favorable to the occurrence and development of the disease [2].

Sclerotinia sclerotiorum is a necrotrophic and polyphagous pathogen possessing a vast spectrum of hosts, roughly 408 agricultural crops, of which the most important in terms of economic are soybean, common beans and cotton. Moreover, the fungus in question has a natural ability to form resistance structures, named sclerotium, which can survive in the soil for a period of time, varying from 3 to 8 years, even under adverse environmental conditions [3].

The soybean grains geometric mean diameter increased from 4.83 to 5.27 mm and the sphericity increased from 0.8627 to 0.8512 with the increase in moisture content from 10% to 16% (wb). The length, width and thickness change as moisture content ranged from 10 to 16% (wb), the grains length increased from 5.81 to 6.57 mm, width and thickness change from 4.91 to 5.69 mm and 4.11 to 5.53 mm respectively [6].

Separating and cleaning facing a lot of problems because the difference in the engineering characteristics of white mold, therefore machine must adjusted to remove all sclerotia of white mold fungi.

The main objective of this research to determine the differences between the physical properties of soybean and white mold Sclerotia to find the important information properties which can be used in prepare and adjust of separating equipment.

MATERIALS AND METHODS

Experiment was carried out through 2018 at the Department of Agriculture Engineering, Faculty of Agriculture, Tanta University, Egypt, to investigate physical, properties of the American soybeans seeds imported to Egypt. The soybean seeds and white mold dimensions tested under four different moisture content 8.85, 10.80, 11.60, and 12.30%.

Materials- Soybean crops

American soybean seeds were used in this study (Fig.1), and also (*Sclerotinia sclerotiorum*) fungus as shown in Fig. 2.

Fig. 1. American Soybean seeds Source: Author's own illustration.

Fig. 2. White mold Sclerotia Source: Author's own illustration.

Measurements and determinations

Physical properties

The three axial dimensions of seed are namely length "L, in mm" (longest intercept), width "W, in mm" (equatorial width perpendicular to L) and thickness "T, in mm" (breadth perpendicular to L and W), measured by a digital Vernier-caliper with accuracy of 0.01 mm for randomly selected 100 seeds. Mean dimensions of soybean seeds, the arithmetic mean diameter (D_a), mm, geometric mean diameter (D_g), mm, surface area (A_s), mm^2, volume (V), mm^3 and sphericity (φ), % of grains were calculated as:

-***Arithmetic mean diameter*** (D_a), mm:

$$D_a = \frac{(x + y + z)}{3} \ldots\ldots\ldots\ldots(1)$$

-***Geometric mean diameter*** (D_g), mm:

$$D_g = (x.\ y.\ z)^{1/3} \ldots\ldots\ldots\ldots(2)$$

-***Surface area*** (A_s), mm^2:

$$A_s = \pi., D_g^2 \ldots\ldots\ldots\ldots (3)$$

-***Volume*** (V), mm^3:

$$V = \frac{\pi}{6}(x.\ y.\ z) \ldots\ldots\ldots\ldots (4)$$

-***Sphericity*** (φ), %:

$$\varphi = \frac{(x.y.z)^{1/3}}{x} = \frac{D_g}{x} \ldots\ldots\ldots (5)$$

where: x: length of grains (mm),
y: width of grains (mm) and
z: thickness of grains (mm)

-***Density:***

$$\rho = m/v\ (gm./cm^3) \ldots\ldots\ldots\ldots(6)$$

where: m= Mass of sample,(gm.)
v = Volume occupied by the sample, (cm^3).

-***Surface area*:**

$$S_a = \Pi\ (D_g)^2 \ldots\ldots\ldots\ldots(7)$$

- ***Moisture content*** of soybean seeds was determined as dried in an oven of 103°C for 24h. All moisture percentages were determined on wet basis as it is showed in the equations below:

$$M_w = (W_2 - W_1)/W_2\ x100 \ldots\ldots\ldots\ldots (8)$$

where: M_w: Moisture content of soybean seeds sample on wet basis, (%),
W_1: Final mass of soybean seeds sample after drying, (g) and
W_2: Initial mass of soybean seeds sample before drying, (g).

-***Terminal velocity***, drag force and drag coefficient:

An apparatus was designed according to Dilmac et al, (2016) to determine the terminal velocity (Vt) of grains. The drag force (Fd) and drag coefficient (Cd) could be calculated according to Mohsenin, (1986) as follows:

$$Fd = 0.5 \times Vt2 \times \rho a \times As \times Cd \ \ldots\ldots\ldots(9)$$

$$Cd = \frac{2mg(\rho_s - \rho_a)}{\rho_s\ \rho_a A_s V_t^2} \ldots\ldots\ldots\ldots (10)$$

where: m: The mass of the grain (kg),
g: The gravitational acceleration ($m.s^{-2}$),
ρa: The air density (1.191 $kg.m^{-3}$),
ρs: The grains density (true density), ($kg.m^{-3}$),
As: The grain surface area (m^2) and
Vt: The terminal velocity ($m.s^{-1}$).

-***Angle of repose*** was calculated according to Mohsenin, (1986):

$$\theta = \tan{-1}\ (2h/d) \quad \ldots\ldots\ldots\ldots (11)$$

where: θ: Angle of repose, degree,
h: height of pile and d is the diameter of cone, mm
d: Cone diameter, mm.

-***Angle of static friction***

The angle of static friction coefficient (θ) on galvanized metal for wheat grains was calculated according to Mohsenin, (1986):

$$\theta = \tan^{-1}\ (SFC)\ . \quad \ldots\ldots\ldots\ldots (12)$$

where: θ: Angle of static friction, (degree) and
SFC: Coefficient of static friction.

-Bulk density

The bulk estimated according to Mohsenin, (1986). The bulk density is the ratio of the mass of the sample to its container volume. It was measured by weighing a filled measuring cylinder with known volume and calculated as:

$$\rho_b = \frac{m}{V_{total}} \text{ .... } (13)$$

where: ρ_b: Bulk density ($kg.m^{-3}$),
m: Mass (kg) of the sample and
V_{total}: Volume of the sample (m^3).

RESULTS AND DISCUSSIONS

Effect of different moisture content on physical properties of soybean seeds.

In (Fig.3) Linear relationship was obtained between moisture content (Mc) and seed length:

$y = 0.206x + 5.195 \quad R^2 = 0.928 \qquad (14)$

The seed length linearly increased from 5.39 to 5.96 mm with increase moisture content from 8.85 to 12.3% (wb).

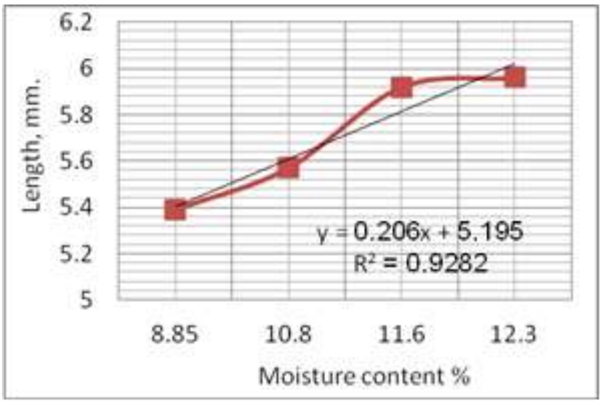

Fig. 3. Relationship between moisture content and seed lenght.
Source: Author determination.

In (Fig. 4). Linear relationship was obtained between moisture content (Mc) and seed width:

$y = 0.134x + 4.65 \quad R^2 = 0.972 \qquad (15)$

The seed width linearly increased from 4.76 to 5.17mm with increase moisture content from 8.85 to 12.3% (wb).

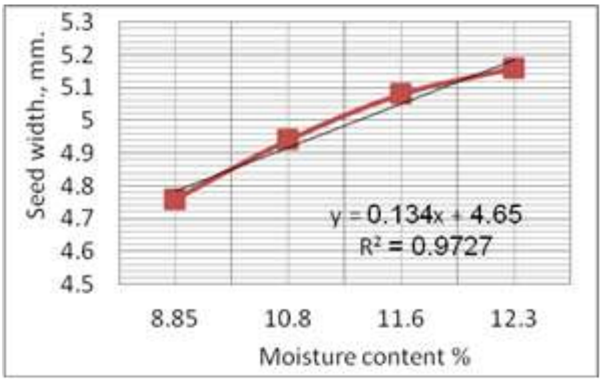

Fig. 4. Relationship between moisture content and seed width.
Source: Author determination.

In (Fig. 5) Linear relationship was obtained between moisture content and seed thickness:

$y = 0.131x + 3.865 \quad R^2 = 0.99 \qquad (16)$

The values of seed thickness linearly increased from 3.98 to 4.38 mm with increase moisture content from 8.85 to 12.3% (wb).

Similar increasing for seed length, width and thickness trends have been reported for soybean seed [3].

The positive linear relationships of seed width and moisture content were also reported by [6] for soybean.

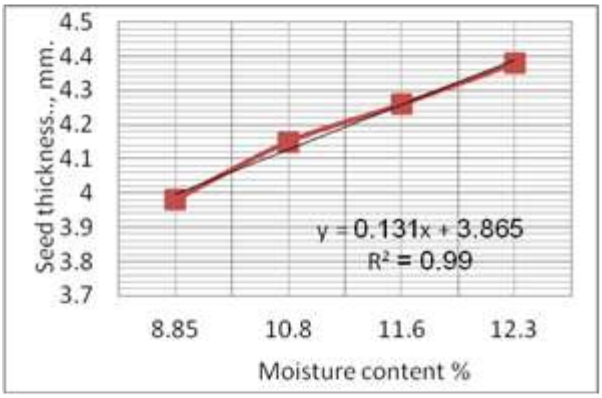

Fig. 5. Relationship between moisture content and seed thickness.
Source: Author determination.

In (Fig. 6). Linear relationship was obtained between moisture content and seed volume:

$y = 5.792x + 50.35 \quad R^2 = 0.931 \qquad (17)$

Volume of seed showed linearly increase from 55.89 to 71.93 mm^3 with increase moisture content from 8.85 to 12.3% (wb).

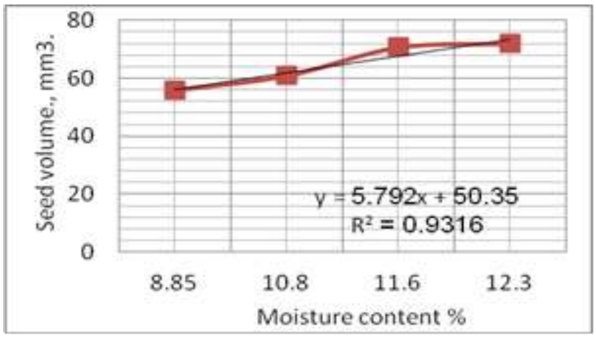

Fig. 6. Relationship between moisture content and seed volume.
Source: Author determination.

In Fig.7. Linear relationship was obtained between moisture content and seed arithmetic diameter:

$y = 0.149x + 4.560 \quad R^2 = 0.904$ (18)

Seed arithmetic diameter ranged from 4.7 to 5.105 mm when moisture content increased from 8.85 to 12.3%.

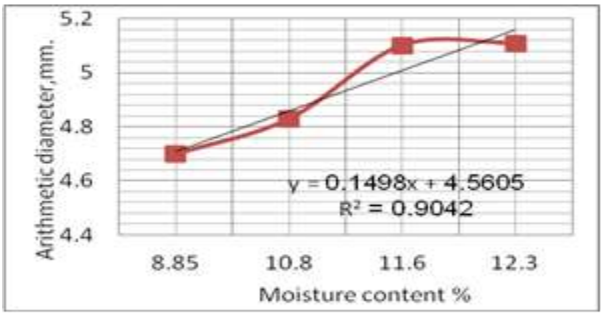

Fig. 7. Relationship between moisture content and seed arithmetic diameter.
Source: Author determination.

In Fig. 8, it is presented seed geometric diameter which ranged from 4.66 to 5.05 mm when moisture content increased from 8.85 to 12.3%. Linear relationship was obtained between moisture content and seed arithmetic diameter:

$y = 0.143x + 4.525 \quad R^2 = 0.905$ (19)

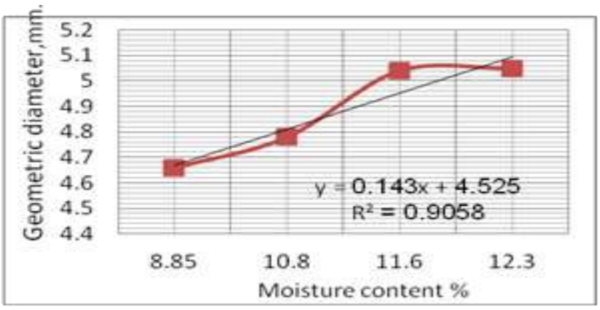

Fig. 8. Relationship between moisture content and seed geometric diameter.
Source: Author determination.

In Fig. 9 it is shown the seed sphirecity which ranged from 86.94 to 85.1% when moisture content increased from 8.85 to 12.3%.

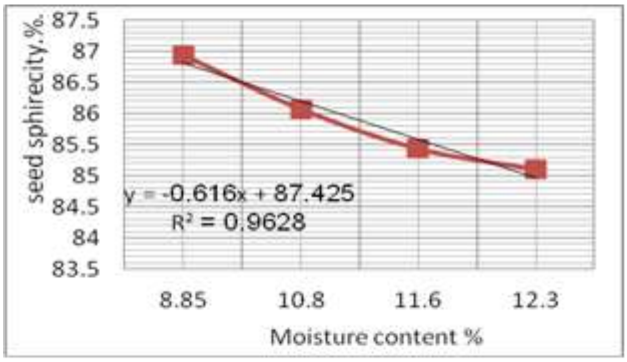

Fig. 9. Relationship between moisture content and seed sphirecity.
Source: Author determination.

Linear relationship was obtained between moisture content and seed sphericity:

$y = -0.616x + 87.42 \quad R^2 = 0.962$ (20)

The result in Fig. 10 indicates that the soybeans surface area increased with 68.29, 71.64, 79.7 and 80.17mm^2 when moisture content increased by 8.85, 10.8, 11.6, and 12.3%. The relationship of surface area and moisture content can be expressed using regression equation:

$y = 4.37x + 64.02 \quad R^2 = 0.908$ (21)

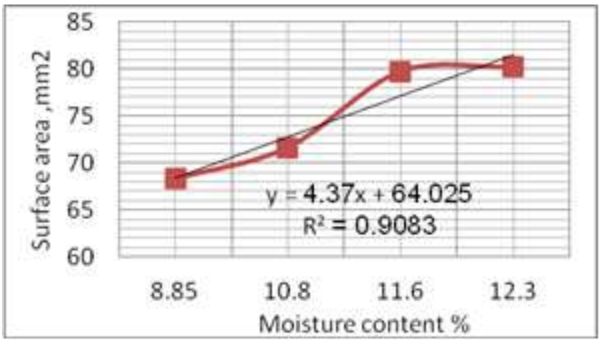

Fig. 10. Relationship between moisture content and seed surface area
Source: Author determination.

Effect of different moisture content on chemical properties of soybean seeds

The chemical analysis of the American soybean seeds affected moisture content. The increasing of moisture content from 8.85% to

12.3 % percentage lead to decrease of the other components of the seed.

Table 1. Chemical properties of soybean seeds

Items	Moisture content%			
	8.85	10.8	11.6	12.3
Oil content%	19.80	19.1	19.7	19.2
Protein%	35.6	34.1	33.2	32.9
Fiber %	5.1	4.97	4.3	4
Colored bean%	0.26	0. 07	0.82	0.89
Foreign matter%	1.2	1.1	0.9	0.7
Total damage %	1.3	1.4	1.5	1.58
Green beans%	0.36	0.12	0.21	0.33
Splits %	6.8	6.68	6.62	6.54
F.F.A	0.42	0.49	0.53	0.61

Source: Own results.

Table 1 shows that oil content was decreased from 19.8 to 19.2 %, protein also was decreased from 35.6 to 32.9%, fibre was decreased from 5.1 to 4 %, foreign matter was decreased from 1.2 to 0.7%, total damage from 1.3 to 1.58, green beans from 0.36 to 0.33, splits 6.8 to 6.54, F.F.A from 0.42 to 0.61.

Physical properties of white mold seeds

The average length, width and thickness of white mold sclerotia ranged from 5.85 to 20.31mm, 1.32 to 4.39mm, 0.88 to 3.07 mm and also volume ranged from 9.75 to 75.19 mm^3 as maximum and minimum value respectively.

The arithmetic diameter ranged from 2.64 to 5.22 mm and geometric mean diameter increased from 3.2 to 8.07 mm. The surface increased from 22 to 85.8 mm^2 and the sphericity increased from 15.98 to 58.18% with maximum and minimum value respectively as shown in Table 2.

Table 2. Some physical properties of white mold (*sclerotina scleriotiorum*)

Parameter	average	Max	Min
Length, mm	10.64	20.31	5.85
Width, mm	2.82	4.39	1.32
Thickness, mm	1.99	3.07	0.88
Volume, mm^3	31.3	75.19	9.75
Arithmetic diameter, mm	5.15	8.07	3.2
Geometric diameter, mm	3.28	5.2	2.64
Sphericity %	38.18	58.18	15.98
Surface, mm^2	46.94	85.85	22.02

Source: Own results.

The differences between the physical properties of white mold sclerotia and soybean seeds.

The average length, width and thickness of white mold sclerotia were ranged from 5.85 to 20.31 mm, and 1.32 to 4.39 mm, thickness from 0.88 to 3.07 mm, geometric mean diameter from 2.64 to 5.22 mm, the arithmetic mean diameter from 3.02 to 8.07 mm and soybean alternated length from 5.39 to 5.96 mm, width from 4.76 to 5.16 mm. Thickness changed from 3.98 to 4.38 mm and geometric mean diameter fluctuated from 4.66 to 5.05 mm. The arithmetic mean diameter from 4.7 to 5.109 mm with maximum and minimum value respectively. At a constant moisture content, 12.3 % (Fig. 11).

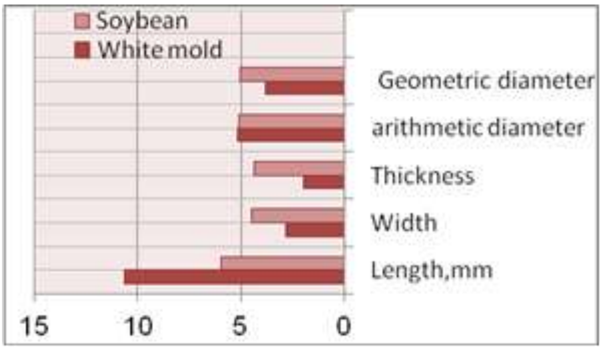

Fig. 11. The differences between some physical properties of white mold sclerotia and soybean seeds
Source: Author determination.

The mechanical properties of soybean.

Terminal velocity ranged from 11.2 - 12 (m/s), Repose angle 29°, Modulus of elasticity £ (μ_{pa})126, Viscosity 0.0406$Pa_{s,}$ Static coefficient of fraction - concert wood float finish 0.52- wood Douglas fire grain par 0.35 - Galvanized sheet metal 0.22, 1,000 grains mass 165 g, bulk density 821.5 kg/m^3 (Table 3).

Table 3. Some mechanical properties soybean seeds

Items	Value
Terminal velocity (m/s)	11.2 - 12
Repose angle (°)	29
Modulus of elasticity £ (μ_{pa})	126
Viscosity(Pa_s)	0.0406
Static co efficient of fraction - concert wood float finish - wood Douglas fire grain par - Galvanized sheet metal	 0.52 0.35 0.22
1,000 grain mass (g)	156
bulk density (kg/m^3)	821.5

Source: Own results.

CONCLUSIONS

The average length, width and thickness of soybean grains ranged from 5.39 to 5.96 mm, 4.76 to 5.16 mm and 3.98 to 4.38 mm as the moisture content increased from 8.85% to 12.3% (wb), respectively. The geometric mean diameter increased from 4.66 to 5.05 mm. and the sphericity decreased from 86.94 to 85.1%. with the increase in moisture content from 8.85% to 12.3% (wb). The average of white mold sclerotia length ranged from 5.85 to 20.31 mm, width from 1.32 to 4.39 mm, thicknesses from 0.88 to 3.07 mm, volume from 9.75 to 75.19 mm^3, geometric mean diameter from 2.64 to 5.22 mm, the arithmetic mean diameter from 3.02 to 8.07 mm, and sphericity from 15.98 to 58.81%. Also surface ranged from 22 to 85.85 mm^2**.**

By determining the physical properties for white mold sclerotia and soybean seeds, the wide range of white mold sclerotia shape changed by moisture content can be monitored to allow chose multiple use of sieves with holes suitable for complete separation. This action lead to reduces the risk of mixing the white mold with soybeans during oil extract production.

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