Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 3, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DETERMINATION OF PHYSICAL PROPERTIES OF SOME SEEDS

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Abstract

The main objective of this research to determine of physical properties of seed related to help in safe passage for seed through cleaning and separation processes. Also investigate some seed properties can be used in design and development of multi-seed planting machine. Soya Bean, Wheat, Corn, Cotton Faba Bean and Sunflowers were tested at department of agriculture engineering, faculty of agriculture, Tanta university, Egypt. through 2022. From the results, it is clear that the little differences in the maximum of Length dimensions between Soya Bean and Wheat were 7.62 and 8.72 mm. ,it increased between Corn and Cotton to 15 and 10.12 mm. and Faba Bean and Sunflowers were 11 and 19 mm. the maximum of Geometric mean diameter recorded little differences between Soya Bean and Wheat were 2.76 and 2.81 mm. ,it increased between Corn and Cotton to 4.83 and 5.13 mm. and Faba Bean and Sunflowers were 8.47 and 6.86 mm.

Key words**:** *soya bean, wheat, corn, cotton, faba bean, sunflower, physical and color properties*

INTRODUCTION

Soya Bean, Wheat, Corn, Cotton, Faba Bean, and Sunflowers are a common food in many countries. For example, the Faba Bean area increased from 187,437 ha to 208,766 and productivity from 810 kg/ha to 1,203 kg/ha, similarly, the soybean area increased from 23,943 to 25,179 ha and productivity from 905 kg/ha to 1,254 kg/ha. Faba beans contain almost twice the protein content as that of cereal grains with globulins (60%), albumins (20%), glutelins (15%), and prolamins (8%), and soybean possesses high protein content from 20% to 41%; the wide variations are due to varietal differences and the source type, that is, fraction, fertilization method, growth season, and planting site [1], [8], [9] and [26].
The physical properties of agricultural materials, such as shape and size, volume, density, porosity, and surface area, are important and necessary engineering data in many problems related to machine design or analysis of the behavior of agricultural products in various processes [23].
At a moisture content of 8.85%, the principal dimensions of soybean seeds were 5.39mm, 4.76mm, and 3.98mm. respectively, and volume, geometric mean diameter, and arithmetic mean diameter were 55.8 mm3,4.66 mm,4.7mm. respectively. The sphericity and surface area was 86.94%, and 68.29 mm^2, respectively [13].
The average dimensions of faba bean seeds with moisture content 10% were, the length 15.077 mm., width 11.187 mm. Thickness 6.1873 mm. Volume 736.69mm^3. geometric mean diameter 10.142mm. The arithmetic mean diameter is 10.817 mm. and sphericity is 65.887%. Also, the surface area is 318.71.mm^2 [21].
The knowledge of physical properties is required for the design of equipment for handling, harvesting, processing and storing. The information related physical properties is not only pertinent to engineers but as well to food scientists, processors, and other scientists who may employ these resources [19].
Zea mays L, kKnown as maize, it is the third most important cereal crop in the world after wheat and rice. It has a very high yield potential and is commonly known as the "Queen of Cereals". Corn contains about 10% proteins, 4% oil, 70% carbohydrates, 2.3%

crude fibre, 10.4% albumen and 1.4% ash. It also contains significant amounts of vitamin A, nicotinic acid, riboflavin and vitamin E. The world produces about 856 million tons of corn, having been recognized as one of the most important crops for food, fodder and industrial purposes. In most parts of the world, corn production is considered one of the world's leading practices whose total production (1,104.88 million metric tons) and yield per unit area, and Egypt's total imports of corn in 2018 amounted to 101,800 metric tons, down 14,200 metric tons or 12% less than in calendar year 2017. Maize is also the staple food of choice for 900 million poor, 120-140 million poor farming families and about a third of malnourished children globally [2], [30], [20].

Maize can be grown successfully in a variety of soil types, ranging from loamy sand to clay loam. These events are influenced by seed interactions, soil moisture, seedling depth, sowing method, equipment type, and so on. Planting methods are critical for the successful establishment of crops in a variety of growing conditions [3].

The physical properties of seeds that play an important role in designing seed metering devices. the grain length, width, thickness, geometric mean diameter, surface area, sphericity, and volume increased linearly from12.53-12.85, 9.12-9.23, and 4.50-4.74 mm, respectively with an increase in moisture content from (12.8-29.0%w.b.). The bulk density and true density decreased from 768.7-665.1 kg m-3 and 1,321.7-1,231.5 kg m^3 respectively with increasing moisture content. The values of geometric diameter, surface area, sphericity, and kernel volume increased from 7.97- 8.21mm,199.87-212.14mm^2, 64.0-64.37%, and 268.25-293.73 mm^3 respectively for an increase of moisture content from12.8-29.0% [6].

Wheat (*Triticum aestivum* L.) is a major cereal crop grown all over the world. It is one of the most important cereal crops grown for human consumption in Africa, as it is classified as a strategic crop for food security and thus contributes about 16% of the needs of some countries, as it provides 21% of the total nutritional requirements to feed 4.5 billion people in developing countries. It covers about 220 million hectares with a production of 716 million tons of food grains with a productivity of 3.2 tons per hectare. It also accounts for nearly 30% of global cereal production and 50% of the global grain trade. According to FAO estimates, the world will need an additional 198 million tons of grain. wheat by 2050 to meet future demands, which will require an increase in wheat production by (77-80%) in emerging countries the need for wheat production has become more important, particularly in the last 50 years. According to figures from the United States Department of Agriculture (USDA), the total grain production rate is about 2.6 billion tons. Wheat accounts for 29% of this [7], [28], [31], [25].

The physical properties of various wheat grain varieties and the dimensions of wheat grain were changed from min to max, respectively, and the length was changed from 4.05 to 4.80 mm. width ranging from 0.10 to 1.22 mm The thickness varied between 0.10 and 1.15 mm. Volume ranged from 0.06 to 3.29 mm^3, geometric mean diameter ranged from 0.48 to 1.85 mm, arithmetic means diameter ranged from 1.53 to 2.36 mm, and sphericity decreased from 38.4 to 10.50 percent. In addition, the surface area increased from 0.72 to 10.70 mm2 at a constant moisture content of 12.2 % [14].

Cotton (Gossypium) seeds contain about 17-24% oil and 40-43% protein, African cotton producing countries are the largest cotton producing zones in the world, they supply from 12–15% of the world's fiber exports. In 2018–2019, these zones supplied 4.5% of the 26 million tons of the world's cotton fiber, almost 3.3 million tons of seed cotton. In 2019, annual seed cotton output ranged from 300,000 to 750,000 tonnes in Africa, which also has the highest yields for rainfed farming, with yields reaching 1 ton per hectare, some of the commercially grown cotton species are, *Gossypium hirsutum* about 90 % of the world is producing this type of cotton, also is grown on approximately 100 million family farms in 75 different countries. According to FAO [18], [10], [17], [24].

Physical properties of cotton seeds. The average length, width, and thickness of cotton seeds ranged from 9.02 to 9.19, 4.70 to 4.86, and 4.25 to 4.45 mm, the sphericity increased from 0.626 to 0.635, seed volume from 95.4 to 109.6 mm^3, and projected area from 35.89 to 40.14 mm^2 [4].

Image analysis was used to determine the physical properties of cotton seeds. The average value of length, width, thickness, geometrical and arithmetic mean diameters, volume, sphericity, coefficient of the contact surface, and surface area of cotton seeds were 9.47, 5.57, 4.68, 6.27, 6.58 mm, 129.55 mm^3, 66.37 %, 50.32 %, and 123.63 mm^2, respectively [5], [27].

Sunflower (*Helianthus annuus* L.) is a popular oilseed crop that is well-known for its high-quality edible oil. Sunflower production in the world is about 47.9 Mt. sunflower is one of the most important oilseed sources. The seeds have a high nutritional value containing moisture 5.50%, protein 18.72%, crude fat 37.47%, crude fiber 28.30%, ash 3.49% and carbohydrates 6.11%. The area under this crop has increased more than 15 times during the last fifteen years indicating strong motivation of the farmers for this crop because it produces 10% of oil in the world [11], [29], [15], [12].

The average of physical properties of sunflower seeds length, width, thickness, geometric and arithmetic mean diameters, volume, sphericity, and surface are 18.39mm, 7.07mm, 3.19mm, 7.41mm, 10.47, 219.04mm^3, 40.44%, 174.17mm^2 respectively [22].

The physical properties of sunflower seeds were evaluated as a function of moisture content. At 6·2% m.c.d.b., the average length, width, thickness and unit mass of the seed were 9·52mm, 5·12mm, 3·27mm, and 0·049g respectively. Corresponding values for the kernel were 8·28mm, 4·09mm, 2·43mm, and 0·034g. The mean equivalent diameter and sphericity of the seed were 5·39mm and 0·57 respectively, while corresponding values for the kernel were 4·32mm and 0·53 [16].

To construction modern device metering for small see drill required essay movement for seeds this is a critically moving during the filling of the feed disk, so must detriments of the small differences in the surface area and topography of the grains and determine some image analyses. The main objective of this research to determine of physical and color properties of seed related to the design of feed mechanism system.

MATERIALS AND METHODS

The experiment was carried out through 2022 at the department of agriculture engineering faculty of agriculture Egypt, to verify the physical and optical properties of different seeds. These characteristics are used in the design and development of a metering device plate. Seeds dimensions were tested under a moisture level of 8 %. The current study was devoted to certain types of grains, which are Faba bean, Soybean, Corn, Wheat, Cotton, Sunflowers which were obtained from the Agricultural Research Centre. Samples were randomly selected and cleaned by hand.

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 manual Vernier-caliper with accuracy of 0.02 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), mm3 and sphericity (φ), % of grains were calculated as:

-Arithmetic mean diameter (Da), mm:

$$Da = \frac{(x+y+z)}{3} \quad \text{.....(1)}$$

-Geometric mean diameter (Dg), mm:

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

-Surface area (A s), mm^2:

$$As = \pi . Dg^2 \text{.....(3)}$$

-Volume (V), mm^3:

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

-Sphericity (φ), %:

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

-Area of flat surface, mm

$$Af = \frac{\pi}{4}(x.y) \text{.....(6)}$$

-Area of transverse surface, mm

$$At = \frac{\pi}{4}(x.z) \quad (7)$$

-Aspect ratio, decimal

$$Ar = \frac{x}{y} * 100 \quad (8)$$

- Shape index, mm

$$SI = \frac{L}{W} * 100 \quad (9)$$

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

RESULTS AND DISCUSSIONS

Physical properties of different grains (Faba bean, soybean, corn, wheat, cotton, sunflowers) were determined, statistically analysed.

Physical Properties

All the experiments for the physical properties of the previously mentioned seeds were carried out with a manual caliper with a precision of 0.02 to show the frequency distribution levels of the seeds at 8% moisture content.

-FABA BEAN

The results showed, the average dimensions of faba bean seeds length ranged from 11 to 22.16 mm., width ranged from 6.22 to 16.2 mm. Thickness ranged from 4.18 to 9.38 mm. Volume ranged from 320.91 to 1,462.9 mm^3. geometric mean diameter ranged from 8.47 to 14.05 mm.

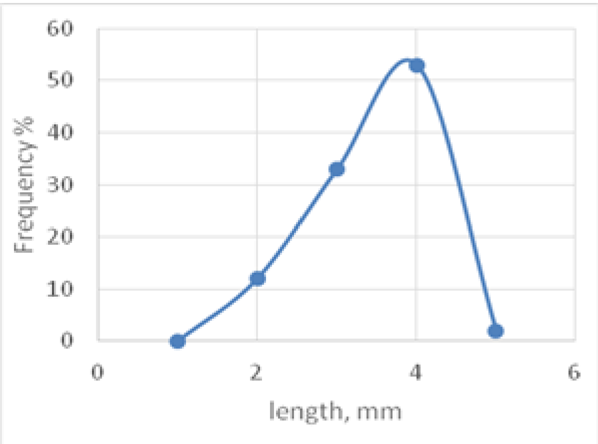

Fig. (A.1). Frequency distribution curves for the length of faba bean seed
Source: Authors' determination.

The arithmetic mean diameter ranged from 8.82 to 15.15 mm. and Sphericity, ranged from 55.33 to 77.85 %. Also, the surface area ranged from 225.67 to 619.8 mm^2.The area of flat surface ranged from 73.24 to 262.73 mm, the area of transverese ranged from 37.69 to 112.06 mm and aspect ratio ranged from 41.46 to 92.66 mm, and the shape index ranged from 107.9 to 241.2 mm.

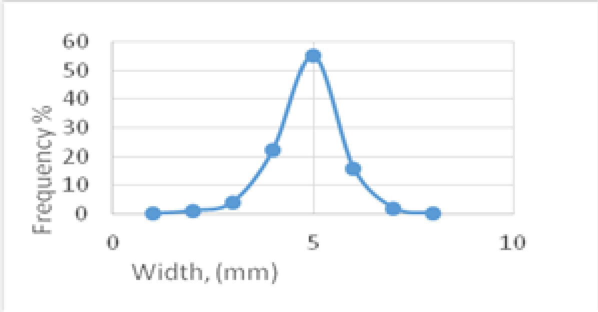

Fig. (A.2). Frequency distribution curves for the width of faba bean seed
Source: Authors' determination.

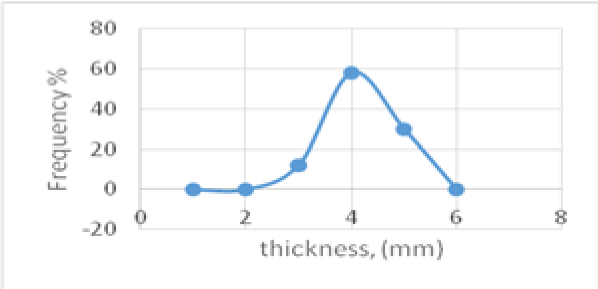

Fig. (A.3). Frequency distribution curves for the thickness of faba bean seed
Source: Authors' determination.

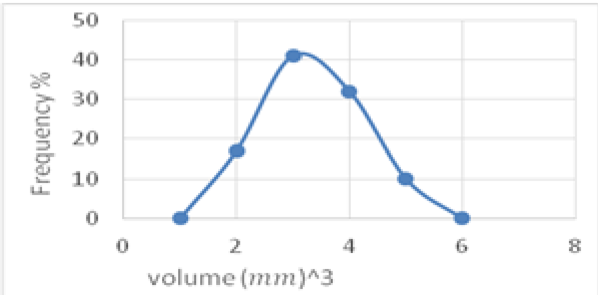

Fig. (A.4). Frequency distribution curves for the volume of faba bean seed
Source: Authors' determination.

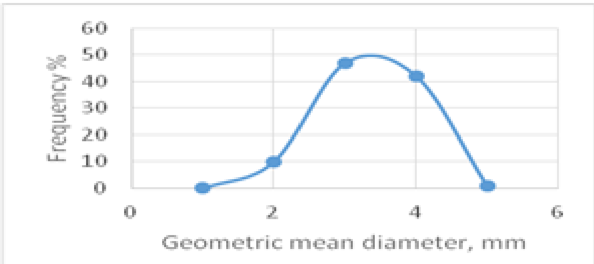

Fig. (A.5). Frequency distribution curves for the geometric mean diameter of faba bean seed
Source: Authors' determination.

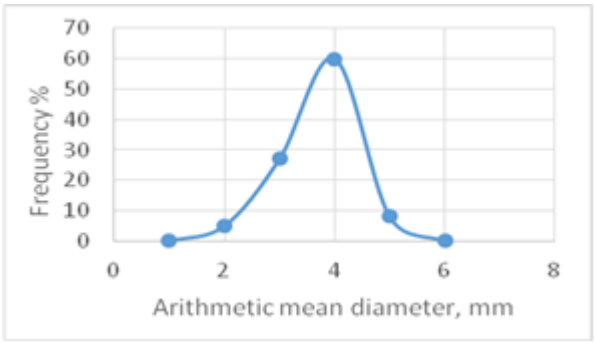

Fig. (A.6). Frequency distribution curves for the arithmetic mean diameter of faba bean seed
Source: Authors' determination.

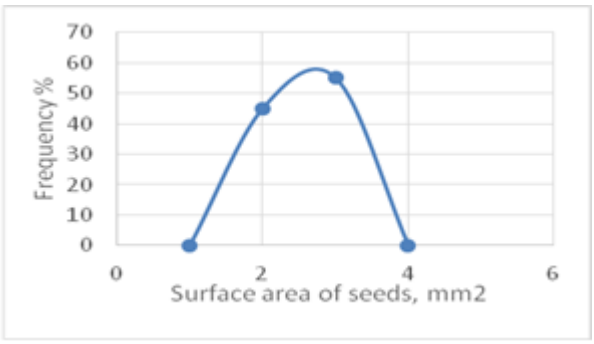

Fig. (A.7). Frequency distribution curves for the area of surface area of faba bean seed
Source: Authors' determination.

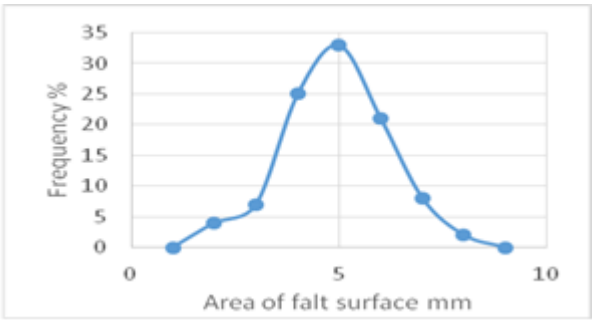

Fig. (A.8). Frequency distribution curves for the area of flat surface of faba bean seed
Source: Authors' determination.

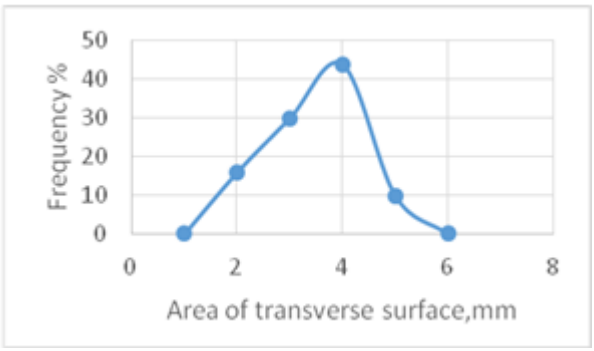

Fig. (A.9). Frequency distribution curves for the area of transverese of faba bean seed
Source: Authors' determination.

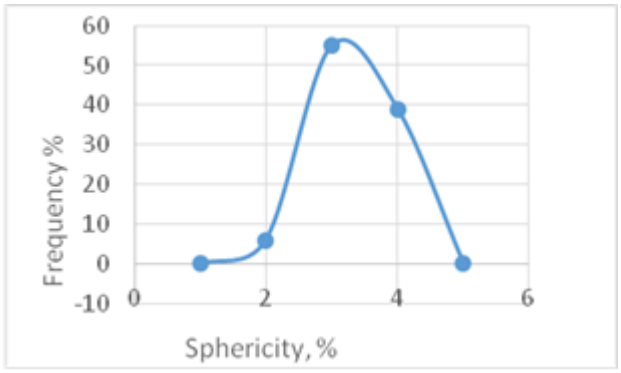

Fig. (A.10). Frequency distribution curves for the sphericity of faba bean seed
Source: Authors' determination.

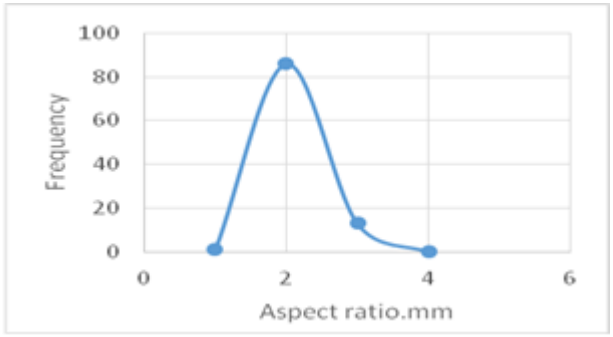

Fig. (A.11). Frequency distribution curves for the aspect ratio of faba bean seed
Source: Authors' determination

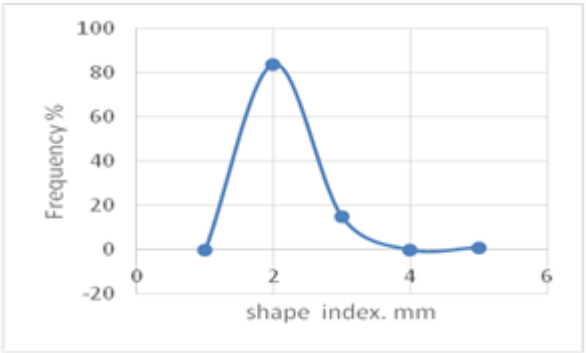

Fig. (A.12): Frequency distribution curves for the shape index of faba bean seed
Source: Authors' determination.

SOYABEAN

The results showed, the average dimensions of soybean seeds length ranged from 4.33 to 7.62 mm., width ranged from 2.46 to 6.33 mm. Thickness ranged from 1.57 to 5.9 mm. Volume ranged from 11.05 to 119.6 mm^3. geometric mean diameter ranged from 8.47 to 14.05 mm. The arithmetic mean diameter ranged from 3.10 to 6.20 mm. and Sphericity, ranged from 103 to 47.01 %. Also, the surface area ranged from 23.93 to 117 mm^2. The area of flat surface ranged from 10.04 to 35.89

mm, the area of transverse ranged from 3.18 to 26.34 mm, and aspect ratio ranged from 44.01 to 129.6 mm, and the shape index ranged from77.18 to 227.2 mm.

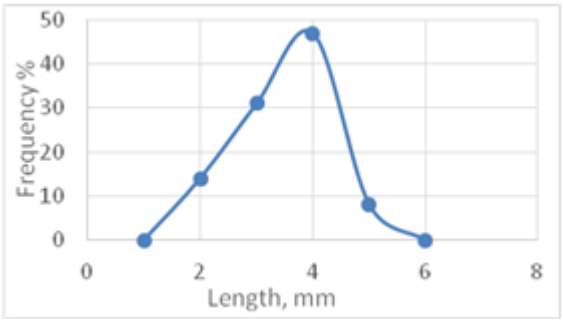

Fig. (B.1). Frequency distribution curves for the length of soya bean seed
Source: Authors' determination.

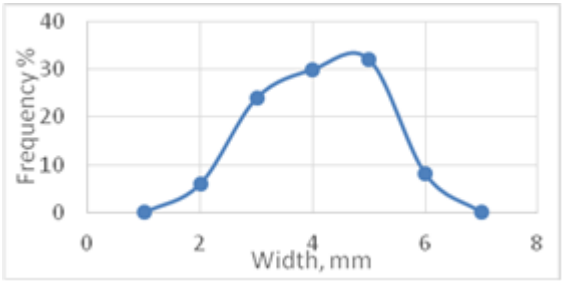

Fig. (B.2). Frequency distribution curves for the width of soya bean seed
Source: Authors' determination.

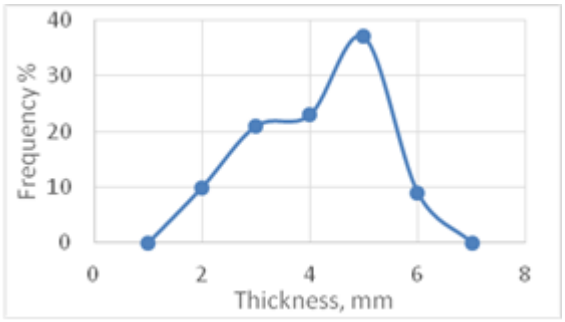

Fig. (B.3). Frequency distribution curves for the width of soya bean seed
Source: Authors' determination.

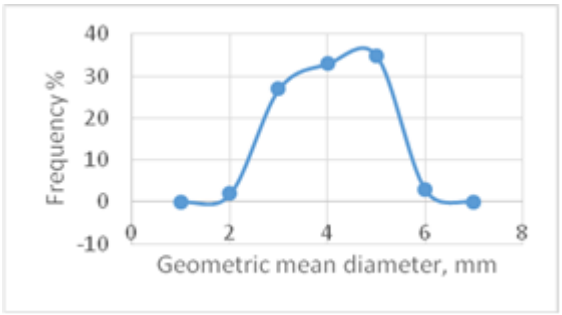

Fig. (B.4). Frequency distribution curves for the geometric mean diameter of soya bean seed Source: Authors' determination

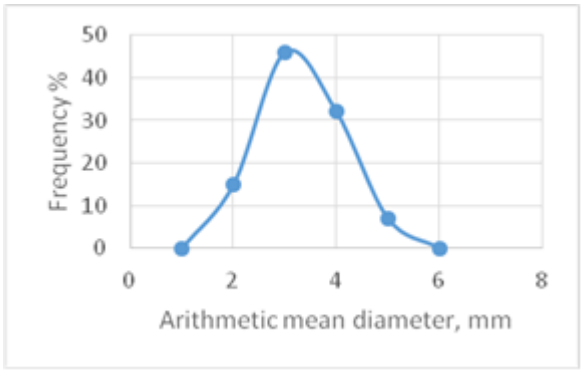

Fig. (B.5). Frequency distribution curves for the arithmetic mean diameter of soya bean seed. Source: Authors' determination

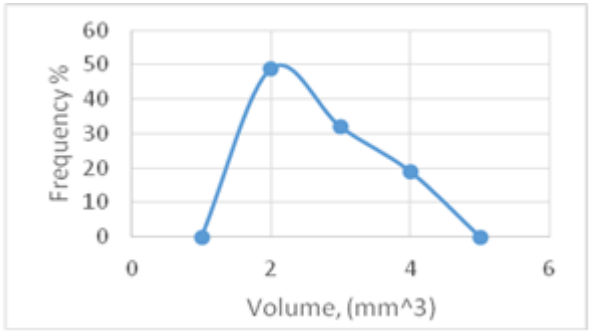

Fig. (B.6): Frequency distribution curves for the volume of soya bean seed
Source: Authors' determination.

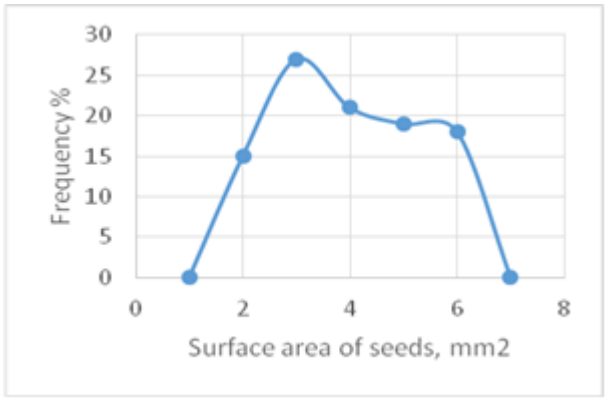

Fig. (B.7). Frequency distribution curves for the surface area of soya bean seed
Source: Authors' determination.

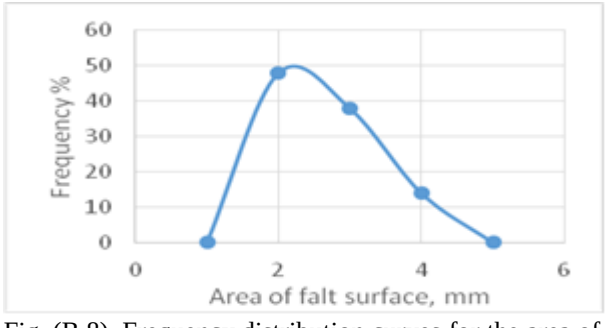

Fig. (B.8). Frequency distribution curves for the area of flat surface of soya bean seed
Source: Authors' determination.

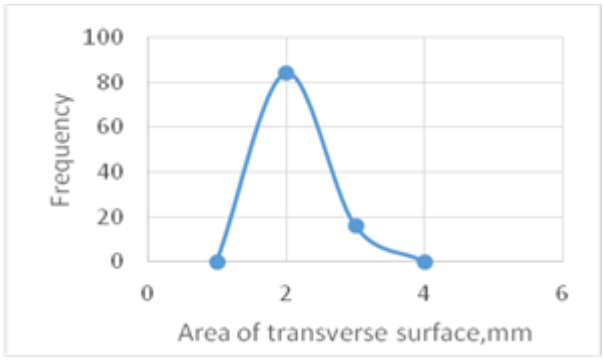

Fig. (B.9). Frequency distribution curves for the area of transverse surface of soya bean seed
Source: Authors' determination.

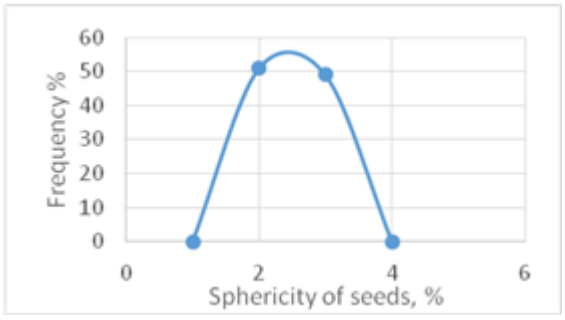

Fig. (B.10). Frequency distribution curves for the sphericity of soya bean seed
Source: Authors' determination.

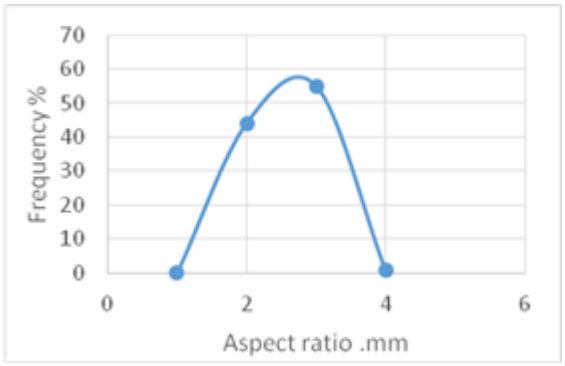

Fig. (B.11). Frequency distribution curves for the aspect ratio of soya bean seed
Source: Authors' determination.

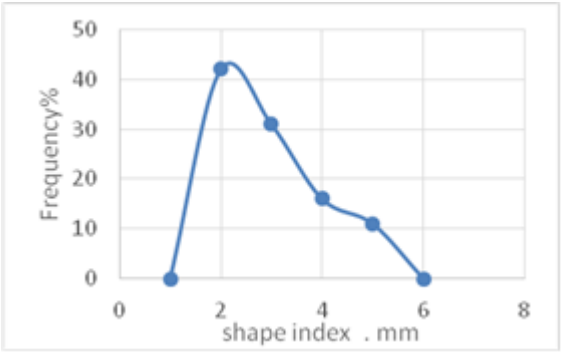

Fig. (B.12). Frequency distribution curves for the shape index of soya bean seed
Source: Authors' determination.

-CORN

The results showed, the average dimensions of corn seeds length ranged from 7.86 to 15 mm., width ranged from 3.7 to 10.12 mm. Thickness ranged from 2.56 to 7.42 mm. Volume ranged from 59.6 to 385.2 mm^3. geometric mean diameter ranged from 4.83 to 9.04 mm. The arithmetic mean diameter ranged from 5.53 to 9.66 mm. and Sphericity, ranged from 96.92 to 49.2 %. Also, the surface area ranged from 73.54 to 254.9 mm^2. The area of flat surface ranged from 28.29 to 106 mm, the area of transverese ranged from 9.17 to 56.54 mm ,and aspect ratio ranged from 37.98 to 100.2 mm, and the shape index ranged from 99.75 to 263.2 mm.

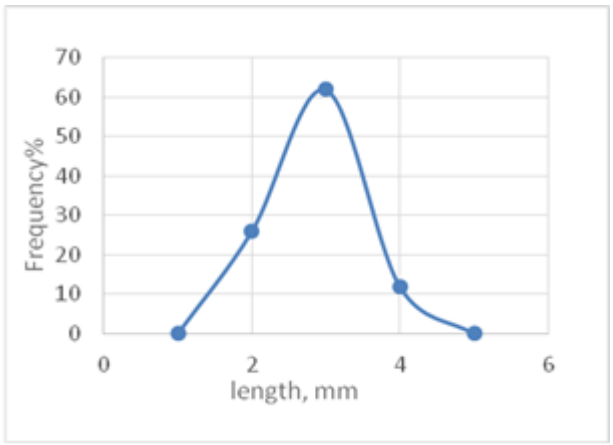

Fig. (C.1). Frequency distribution curves for the length of corn seeds
Source: Authors' determination.

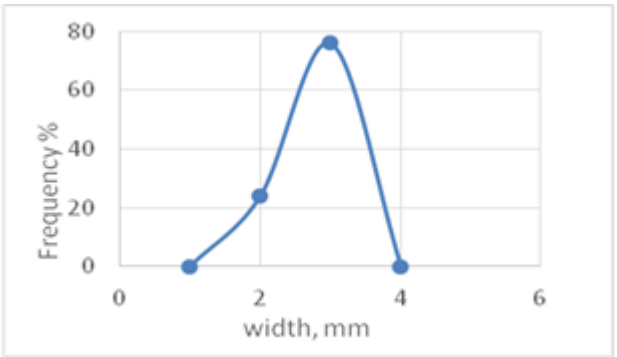

Fig. (C.2). Frequency distribution curves for the width of corn seeds
Source: Authors' determination.

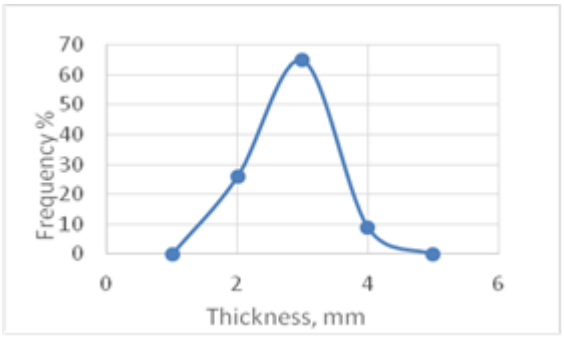

Fig. (C.3). Frequency distribution curves for the thickness of corn seeds
Source: Authors' determination.

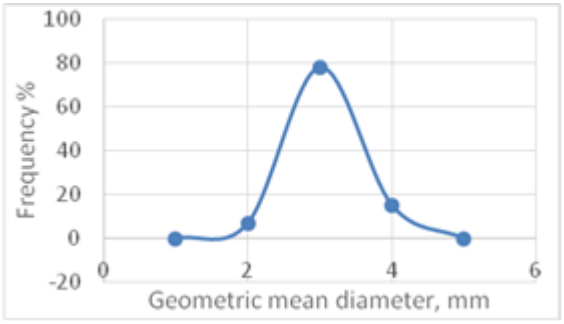

Fig. (C.4). Frequency distribution curves for the geometric mean diameter of corn seeds
Source: Authors' determination.

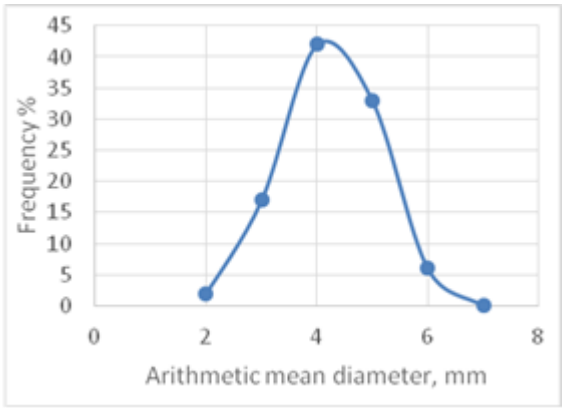

Fig. (C.5). Frequency distribution curves for the arithmetic mean diameter of corn seeds
Source: Authors' determination.

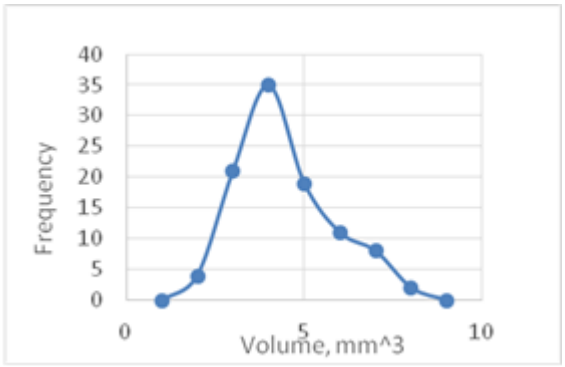

Fig. (C.6): Frequency distribution curves for the volume of corn seeds
Source: Authors' determination.

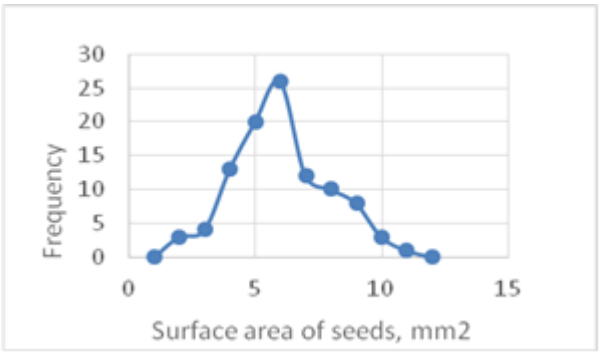

Fig. (C.7). Frequency distribution curves for the surface area of corn seeds
Source: Authors' determination.

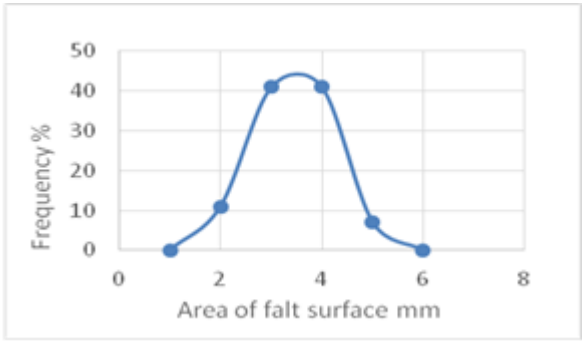

Fig. (C.8). Frequency distribution curves for the area of flat surface of corn seeds
Source: Authors' determination.

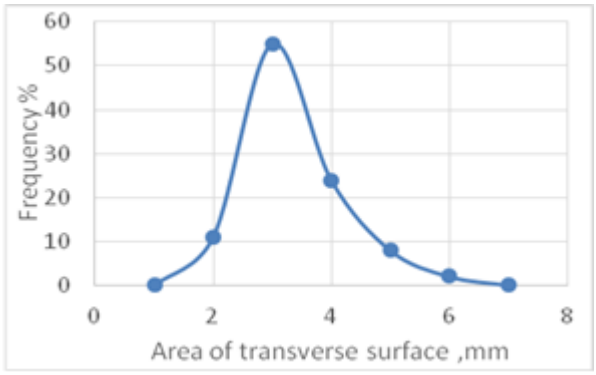

Fig. (C.9). Frequency distribution curves for the area transverse surface of corn seeds
Source: Authors' determination.

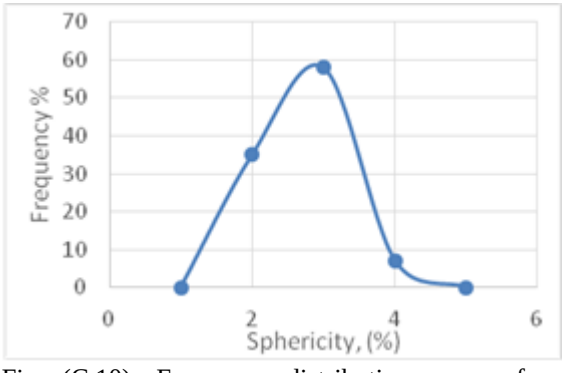

Fig. (C.10). Frequency distribution curves for the sphericity% of corn seeds
Source: Authors' determination.

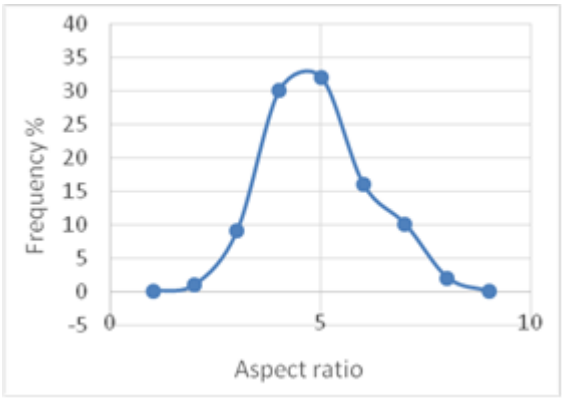

Fig. (C.11). Frequency distribution curves for the aspect ratio of corn seeds
Source: Authors' determination.

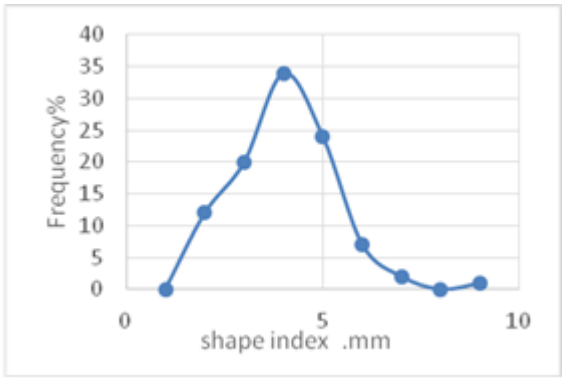

Fig. (C.12). Frequency distribution curves for the shape index of corn seed
Source: Authors' determination

-WHEAT

The results showed, the average dimensions of wheat seeds length ranged from 4.8 to 8.72 mm., width ranged from 2.34 to 5.74 mm. Thickness ranged from 1.68 to 4.98 mm. Volume ranged from 11.73 to 124.68 mm^3. geometric mean diameter ranged from 2.81 to 6.18 mm.

The arithmetic mean diameter ranged from 3.08 to 6.40 mm. and Sphericity, ranged from 79.63 to 45.59 %.

Also, the surface area ranged from 24.91 to 120.2 mm^2.

The area of flat surface ranged from 10.21 to 39.29 mm, the area of transverese ranged from 3.66 to 21.45 mm ,and aspect ratio ranged from 30.96 to 88.85 mm, and the shape index ranged from 112.5 to 323 mm.

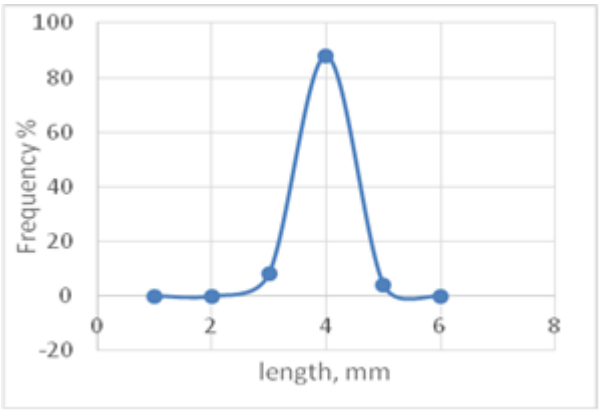

Fig. (D.1). Frequency distribution curves for the length of wheat seeds
Source: Authors' determination.

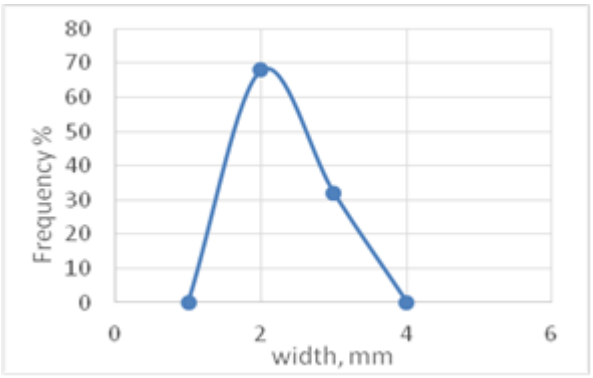

Fig. (D.2). Frequency distribution curves for the width of wheat seeds
Source: Authors' determination.

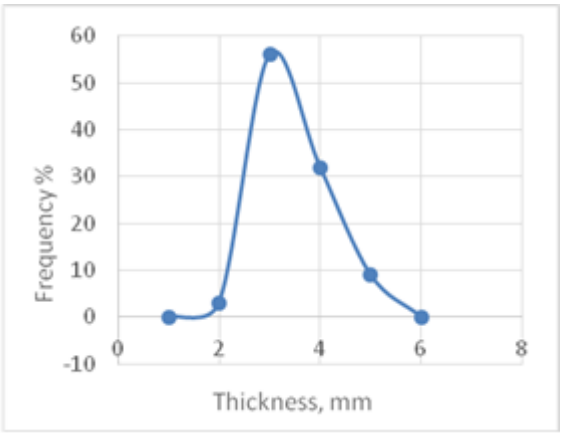

Fig. (D.3). Frequency distribution curves for the thickness of wheat seeds
Source: Authors' determination.

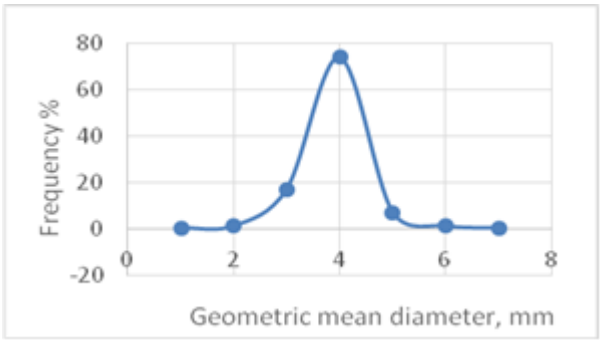

Fig. (D.4). Frequency distribution curves for the Geometric mean diameter of wheat seeds
Source: Authors' determination.

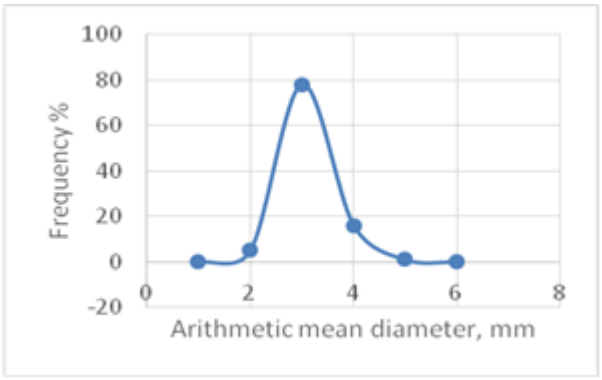

Fig. (D.5). Frequency distribution curves for the arithmetic mean diameter of wheat seeds
Source: Authors' determination.

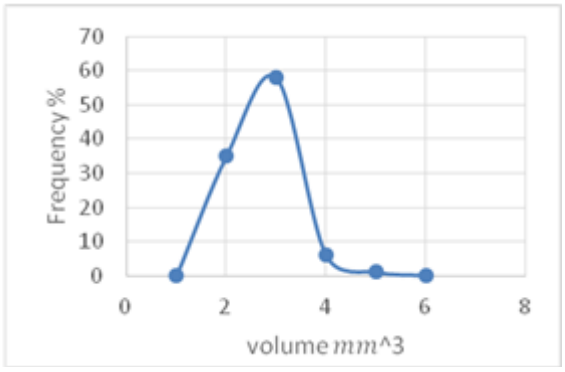

Fig. (D.6). Frequency distribution curves for the volume of wheat seeds
Source: Authors' determination.

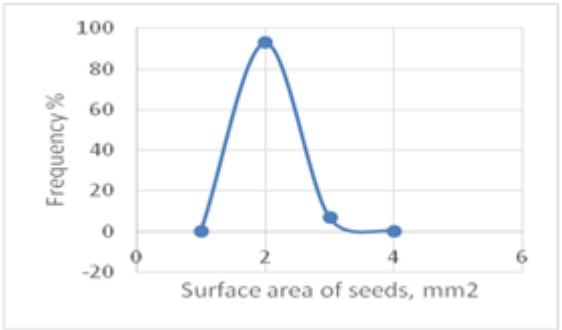

Fig. (D.7). Frequency distribution curves for the surface area of wheat seeds
Source: Authors' determination.

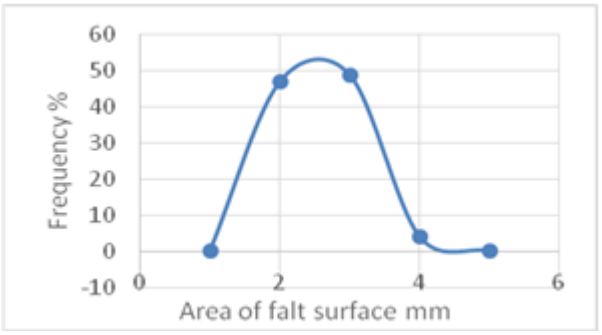

Fig. (D.8). Frequency distribution curves for the area flat surface of wheat seeds
Source: Authors' determination.

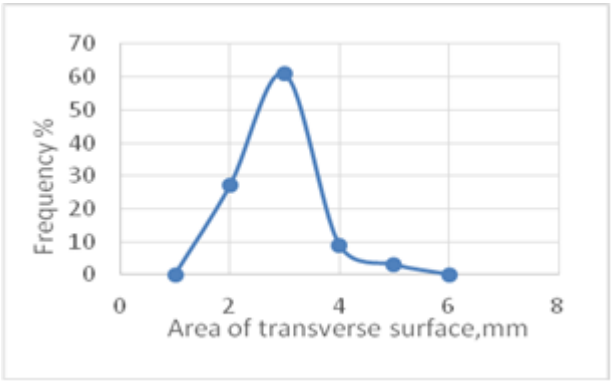

Fig. (D.9). Frequency distribution curves for the area transverse surface diameter of wheat seeds
Source: Authors' determination.

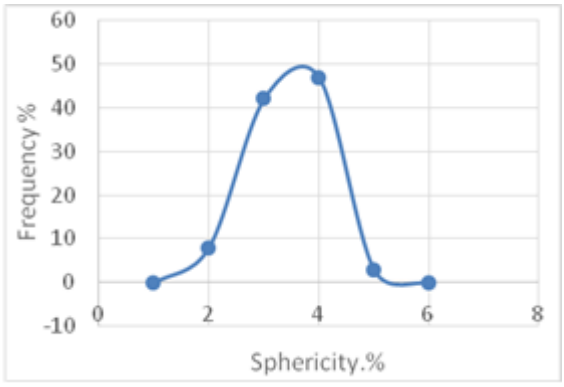

Fig. (D.10). Frequency distribution curves for the sphericity% of wheat seeds
Source: Authors' determination

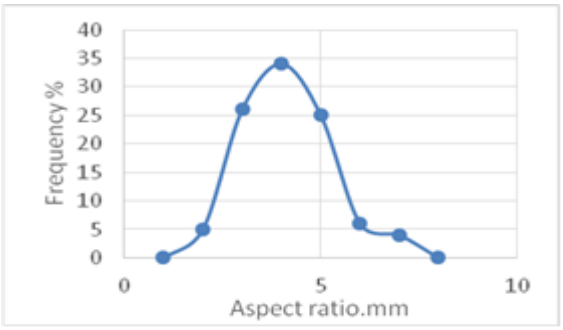

Fig. (D.11). Frequency distribution curves for the aspect ratio of wheat seeds
Source: Authors' determination.

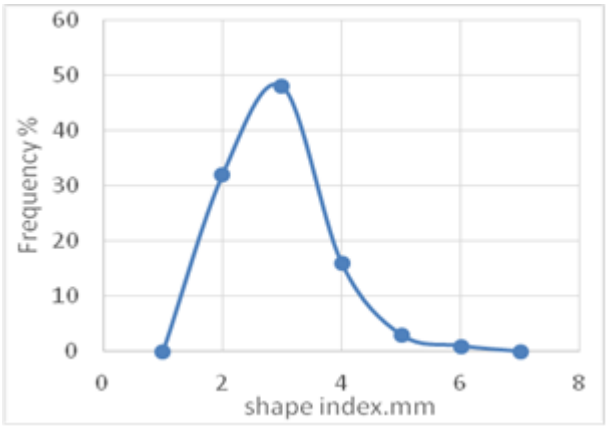

Fig. (D.12). Frequency distribution curves for the shape index of wheat seed
Source: Authors' determination.

-COTTON

The results showed, the average dimensions of cotton seeds length ranged from 7.16 to 10.12 mm., width from 4.42 to 6.92 mm. Thickness ranged from 3.72 to 6.44 mm. Volume ranged from 71.32 to 180.47 mm^3. geometric mean diameter ranged from 5.13 to 6.98 mm. The arithmetic mean diameter ranged from 5.3 to 7.24 mm. and Sphericity, ranged from 85.66 to 56.97 %. Also, the surface area ranged from 82.88 to 153.81 mm2. The area of flat surface ranged from 25.96 to 51.96 mm, the area of transverese ranged from 13.94 to 29.76 mm ,and aspect ratio ranged from 44.75 to 90.33 mm, and rhe shape index ranged from 110.69 to 223.42 mm.

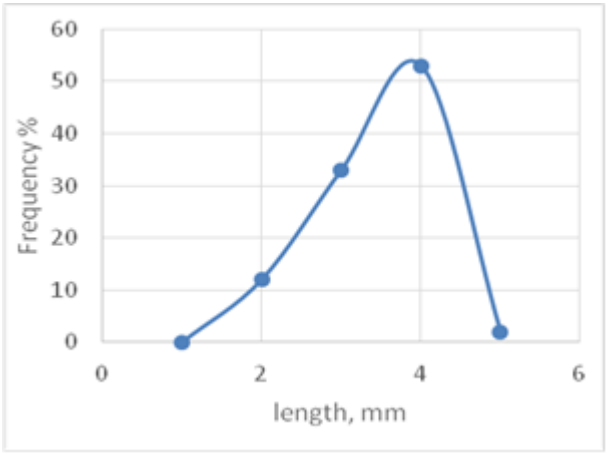

Fig. (E.1). Frequency distribution curves for the length of cotton seeds
Source: Authors' determination.

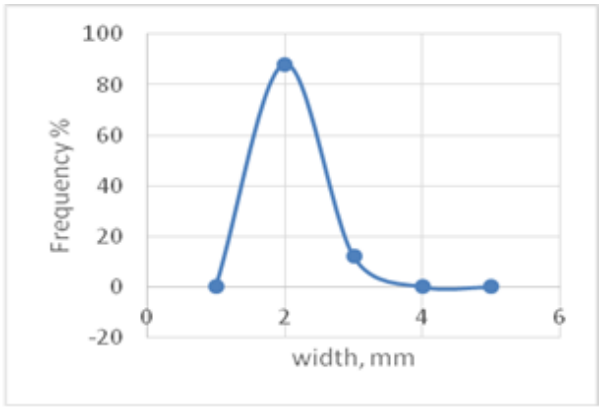

Fig. (E.2). Frequency distribution curves for the width of cotton seeds
Source: Authors' determination.

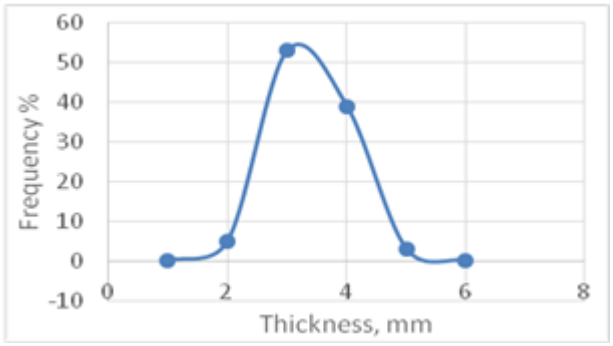

Fig. (E.3). Frequency distribution curves for the thickness of cotton seeds
Source: Authors' determination.

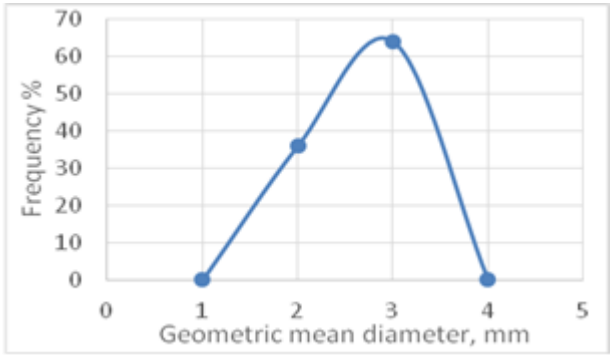

Fig. (E.4). Frequency distribution curves for the Geometric mean diameter of cotton seeds
Source: Authors' determination.

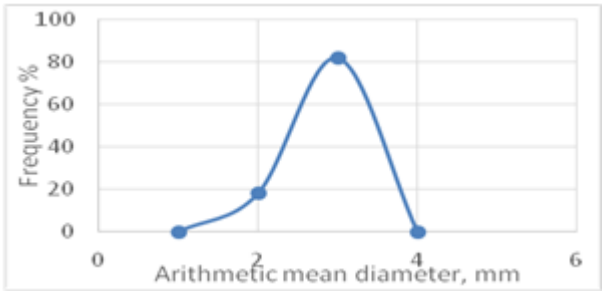

Fig. (E.5). Frequency distribution curves for the Arithmetic mean diameter of cotton seeds
Source: Authors' determination.

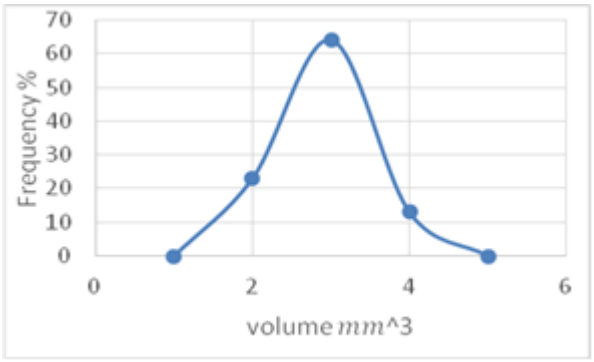

Fig. (E.6). Frequency distribution curves for the Volume of cotton seeds
Source: Authors' determination.

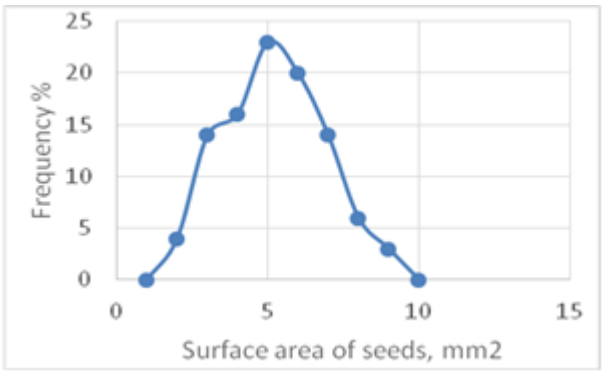

Fig. (E.7). Frequency distribution curves for the Surface area of cotton seeds
Source: Authors' determination.

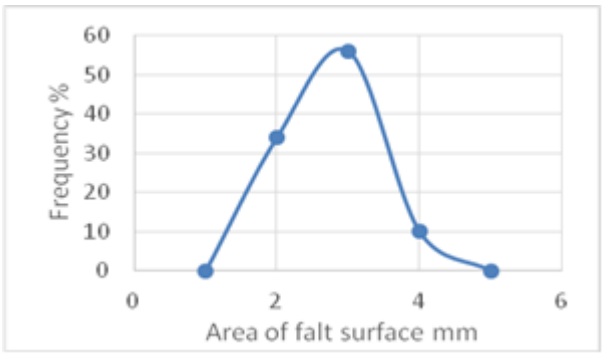

Fig. (E.8). Frequency distribution curves for the Area of flat surface of cotton seeds
Source: Authors' determination.

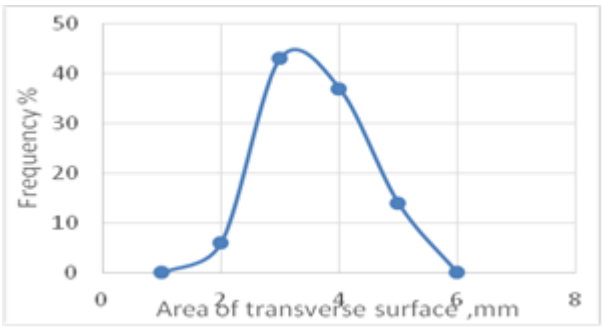

Fig. (E.9). Frequency distribution curves for the Area of transverse surface of cotton seeds
Source: Authors' determination.

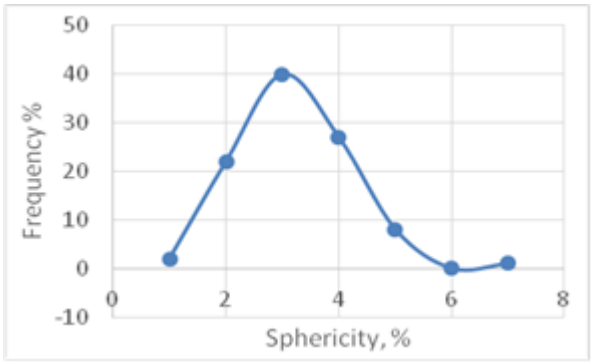

Fig. (E.10). Frequency distribution curves for the Sphericity of cotton seeds
Source: Authors' determination.

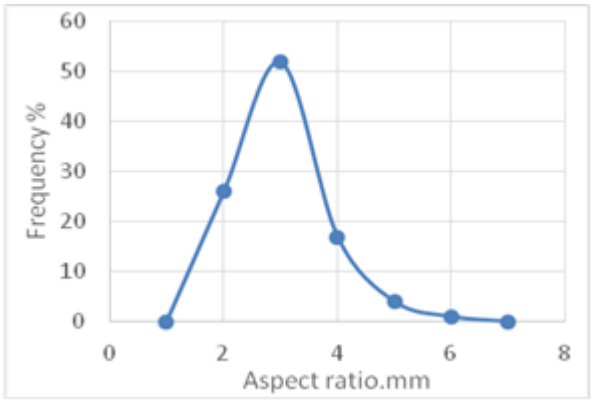

Fig. (E.11). Frequency distribution curves for the Aspect ratio of cotton seeds
Source: Authors' determination.

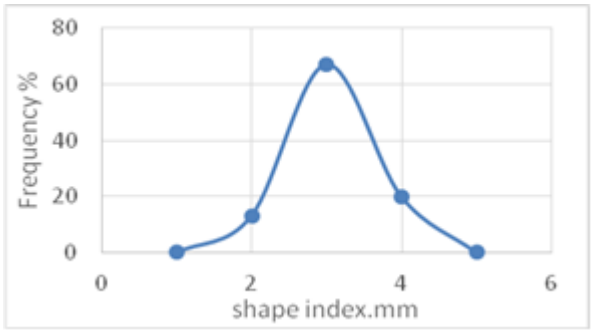

Fig. (E.12). Frequency distribution curves for the shape index of cotton seed
Source: Authors' determination.

-SUNFLOWER

The results showed, the average dimensions of sunflowers seeds length ranged from 19 to 26.12 mm., width ranged from 6.88 to 11.18 mm. Thickness ranged from 2.4 to 6.22 mm. Volume ranged from170.06 to 937.47 mm^3. geometric mean diameter ranged from 6.86 to 12.11 mm. The arithmetic mean ranged from 9.65 to 14.38 mm. and Sphericity, ranged from 51.49 to 33.75 %. Also, the surface area ranged from 147.84 to 460.84 mm^2. The area of flat surface ranged from 102.62 to 226.08

mm, the area of transverese ranged from 12.96 to 54.58 mm ,and aspect ratio ranged from29.72 to 52.73 mm, and the shape index ranged from 189.62 to 336.44 mm.

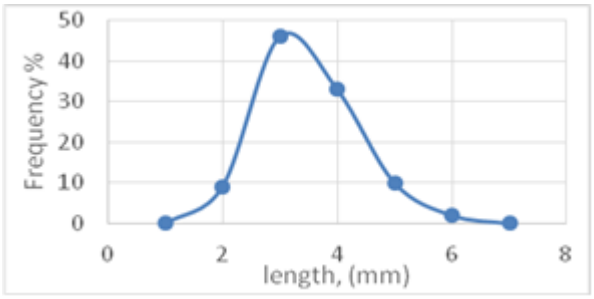

Fig. (F.1). Frequency distribution curves for the length of Sunflower seeds
Source: Authors' determination.

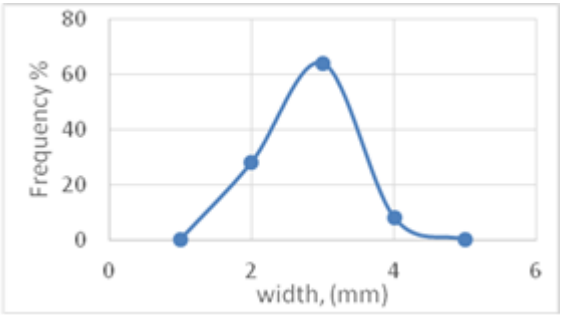

Fig. (F.2). Frequency distribution curves for the width of Sunflower seeds
Source: Authors' determination.

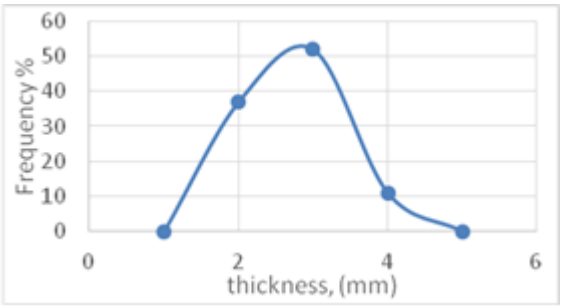

Fig. (F.3). Frequency distribution curves for the thickness of Sunflower seeds
Source: Authors' determination.

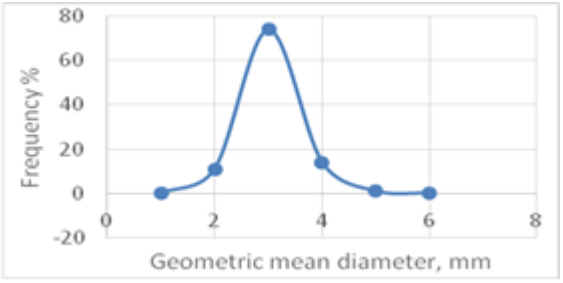

Fig. (F.4). Frequency distribution curves for the Geometric mean diameter of Sunflower seeds. Source: Authors' determination.

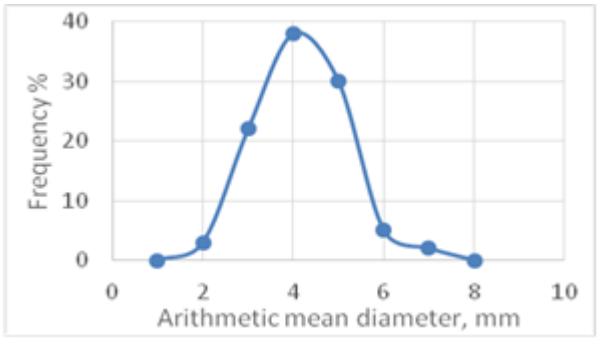

Fig. (F5). Frequency distribution curves for the Arithmetic mean diameter of Sunflower seeds
Source: Authors' determination.

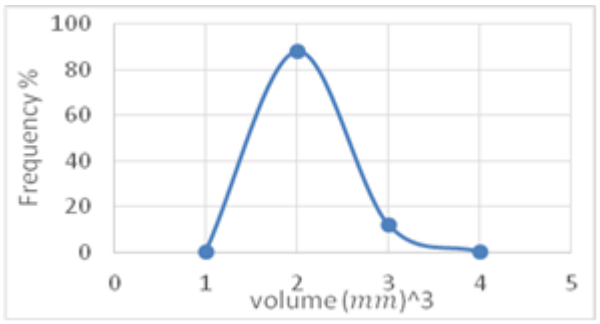

Fig. (F.6). Frequency distribution curves for the Volume of Sunflower seeds
Source: Authors' determination.

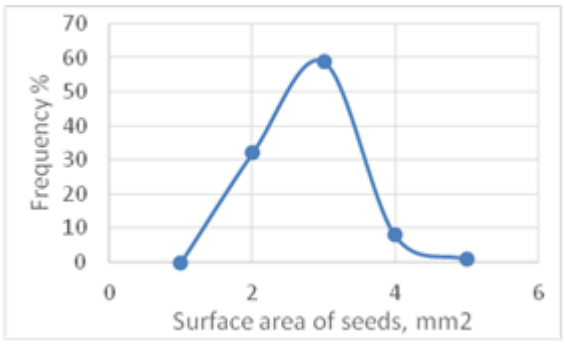

Fig. (F.7). Frequency distribution curves for the Surface area of Sunflower seeds
Source: Authors' determination.

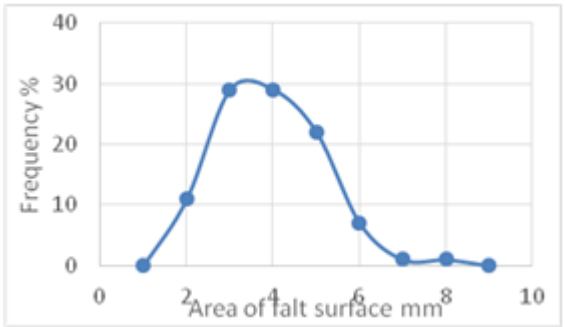

Fig. (F.8). Frequency distribution curves for the Area of flat surface of Sunflower seeds
Source: Authors' determination.

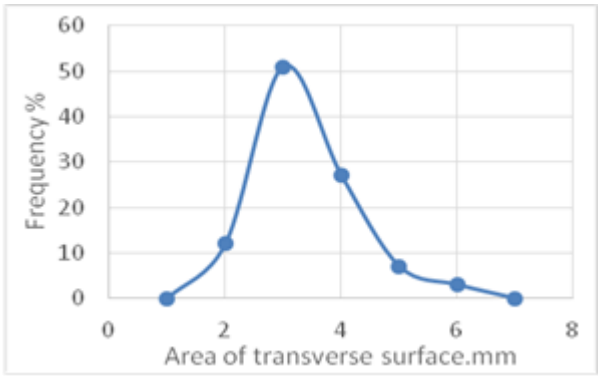

Fig. (F.9). Frequency distribution curves for the Area of transverse surface of Sunflower seeds
Source: Authors' determination.

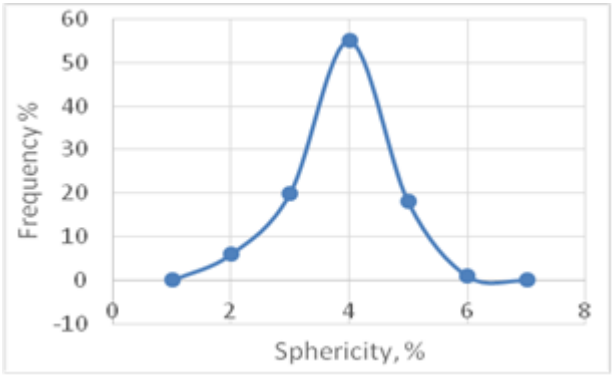

Fig. (F.10). Frequency distribution curves for the Sphericity of Sunflower seeds
Source: Authors' determination.

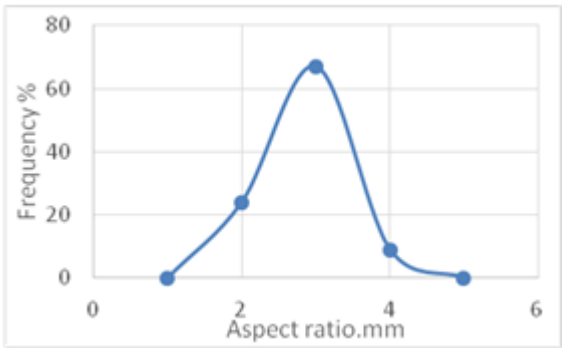

Fig. (F.11). Frequency distribution curves for the Aspect ratio of Sunflower seeds
Source: Authors' determination.

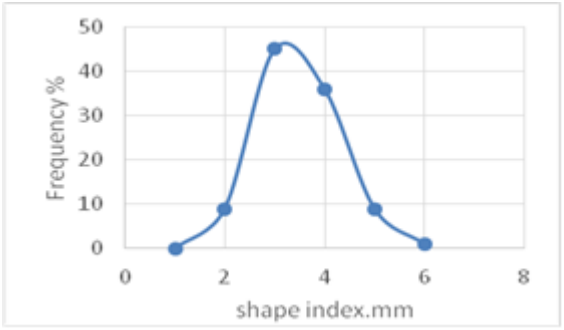

Fig. (F.12). Frequency distribution curves for the shape index of sunflower seed
Source: Authors' determination.

CONCLUSIONS

The small difference in length, width and thickness must be determined in the same variety of grain, as well as the grain that is similar in physical specifications and different in the variety, and this helps in the design of multi-purpose equipment

In this context, we need a database of physical specifications for cultivar-grained grains to help determine shape and size specifications for designing a metring device that fits many grains.

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