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DETERMINATION OF PHYSICAL AND MECHANICAL PROPERTIES OF FUZZY COTTONSEED

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Annotation. *The article presents the results of an experimental study of the physical and mechanical properties of fuzzy seed, which has a unique character. Moisture content, main geometrical parameters, bulk and true density, projection surface and necessary non-mechanical properties in the design of the seed feeder device were determined for five types of seed varieties.*

Key words. *Cottonseed, fuzzy cottonseed, rotary feeder, moisture content, principal dimensions, average diameter, volume, sphericity, coefficient of contact surface, surface area, mass, bulk density, true density, porosity, project area, repose angle, coefficient of static friction, rupture force and deformation ratio.*

Introduction. In the 2023 report of the United States Department of Agriculture (USDA), it was noted that Uzbekistan is experiencing significant changes in cotton production, consumption and industrial practices. Establishing large-scale production enterprises in the field of cotton materials processing, increasing their technical and technological capabilities in accordance with world standards is gaining urgent importance.

Today, cotton is widely grown in the Republic of Uzbekistan as a textile and food source. Most of the local population consumes cottonseed oil. Cottonseed contains about 16-25% fat and 35-45% protein. According to the conducted research, it is important to study the physical and mechanical properties of the seed when determining the geometric, kinematic and dynamic parameters of the technical technological devices of the seed processing industry. In this regard, many researchers of the world determined the physical and mechanical properties of various agricultural products [1-6]. Including shape and size, volume, density, porosity and surface area are important and essential engineering data in many problems associated with design of machines or analysis of the behavior of the agricultural products in different processes [1].

Although various physical and mechanical properties of cotton seeds have been studied to date, it is necessary to take into account the climatic conditions of the regions, the available hairy seeds in the real-time system, and take them into account in the design of technical and technological devices.

In the research carried out on the scale of the republic, no research was carried out on the specific physical and mechanical properties of hairy seeds of cotton varieties grown today. Also, the individual mass of hairy seeds affects various physical properties. The research conducted was devoted to the determination of various physical and mechanical properties of hairy seeds of five leading varieties.

In the course of our research, it was aimed to develop a new effective construction of the hopper and rotary feeder on a comprehensive analysis of the seed supply device used in the technological system of oil extraction from cotton seed today, and to develop energy-saving constructions of the chain transmission as a transmission mechanism. The task of continuous supply of required amount of seed

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to linters in vegetable oil production enterprises is carried out with the help of rotary feeders that work in complex with the hopper. It is the development of the construction of the supplier that fully meets the physical and mechanical properties of the seed that gives the opportunity to increase work performance and economic efficiency.

We started our research by determining the physical and mechanical properties of fuzzy cottonseed. It is important to study the physical and mechanical properties of fuzzy cottonseed when developing an effective construction of a supply device for fuzzy cottonseed. In the course of our research, we selected five types of seed samples that are processed today in the technological system of oil production from plants. Fuzzy cottonseed moisture content, basic linear dimensions, average volume and diameter, sphericity, contact surface coefficient, surface area, bulk and true density, mass, porosity, projection surface, repose angle, coefficient of static friction, bursting strength and determining the values of the deformation coefficients is important in the design of the feather seed feeder device. To determine the mechanical properties of the seed, it is important to conduct research on the seeds of cotton varieties that have high productivity and are being cultivated today. Based on the results of the conducted research [1-5], it can be noted that in enterprises specializing in extracting oil from cotton seed, the linting process is carried out because the seed is not fully depilated. The task of supplying the necessary amount of seed to the linters is carried out by means of the supply unit. Therefore, it is necessary to take into account the specific physical and mechanical properties of fuzzy cottonseed when developing the design of the device for determining and ensuring the physical-mechanical properties of non-fuzzy seed [6.]

Determination of the moisture content of the seed. Existing seed varieties processed at the enterprise were selected for the experiment (Fig. 1). 500 pieces of each variety of seeds were separated and placed in special containers of known weight (Fig. 2. a).

Figure 1. Fuzzy cottonseed sample varieties

When determining the weight of the seed, it was carried out using an analytical balance (Nimbus Analytical Balances > NBL 124e) with a maximum limit value of 120 and an accuracy of 0.0001 grams (Fig. 2 b). The weighed samples were then placed in a Memmet UN30 drying oven cabinet. The seeds were dried at a temperature of 105°C for 3 hours by directing the flow of hot air (Fig. 3).

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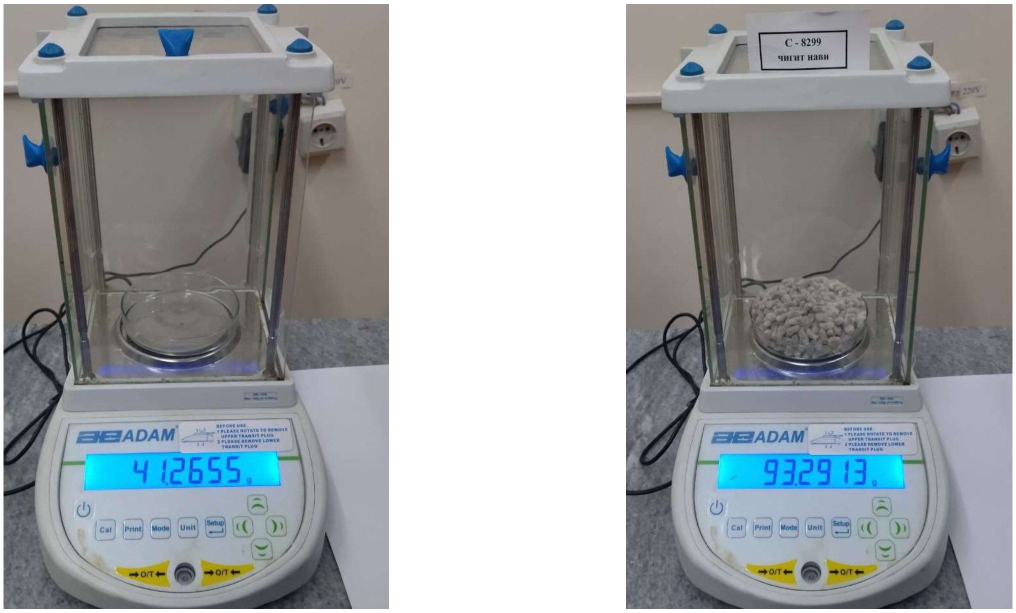

a *b*

Figure 2.2. Determining the weight of seeds. a- determine the weight of the container, b- determine the weight of 500 seeds

Figure 2.3. Seed drying process

Then the seed was taken and cooled in a desiccator. The weight of the cooled seed is determined using a re-analytical scale. The measurement results are detailed in Table 1.

The moisture content M_n is determined by the following expression based on the initial and after drying weights of the seeds [6]

$$M_n = \frac{W_1 - W_2}{W_1} \times 100, \quad (1)$$

Where: $W_1 -$ seed before drying, g; $W_2 -$ weight after drying, g.

Table.1

№	Sort of seeds	Weight before drying W_1, g	Weight after drying, W_2, g	Moisture content M_n
1	C-6575	50,0300	44,9585	10,1369

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2	C-8280	49,2678	44,3925	9,8955
3	C-8299	57,4125	52,1666	9,0862
4	C-8295	62,0367	56,9176	8,2517
5	C-8296	56,8782	51,2917	9,8219

The main dimensions of the fuzzy cottonseed. The length, width, and thickness of the 50 seeds under study were determined using a digital caliper that allows measurement with an accuracy of 0.01 mm. The average indicators of the obtained values are presented in Table 2.

Table.2

№	Sort of seeds	The length of the seed l_{ch}, mm	The width of the seed b_{ch}, mm	The thickness of the seed h_{ch}, mm
1.	C-6575	9,1500	5,2430	5,2450
2.	C-6580	9,1435	4,9705	4,9800
3.	C-8299	9,8050	5,6500	5,6590
4.	C-8295	10,1000	5,7010	5,7000
5.	C-8296	10,0200	5,3000	5,4000

Average seed diameter and size. Average geometric diameter of the seed $-D_g$, average arithmetic diameter $-D_a$ and size$-V_{ch}$ defined by the following expressions [8]:

$$D_g = \sqrt[3]{l_{ch} \cdot b_{ch} \cdot h_{ch}}, \qquad (2)$$

$$D_a = \frac{l_{ch}+b_{ch}+h_{ch}}{3}, \qquad (3)$$

$$V_{ch} = \frac{\pi}{6}(l_{ch} \cdot b_{ch} \cdot h_{ch}). \qquad (4)$$

The seed sphericity value was determined by the following expression using the method proposed by Nuri N. Mohsenin [6]:

$$\Phi = \frac{\sqrt[3]{l_{ch} b_{ch} h_{ch}}}{l_{ch}} \cdot 100; \qquad (5)$$

Where: $l_{ch} -$ the length of the seed; $b_{ch} -$ the width of the seed, $h_{ch} -$ seed thickness.

The average geometric diameter, arithmetic average diameter, volume and sphericity values of the seed according to cotton varieties are determined by expressions (2), (3), (4) and (5) and are presented in Table 3.

Table.3

№	Sort of seeds	D_g, mm	$-D_a, mm$	$-V_{ch}, mm^3$	Φ
1.	C-6575	6,3131	6,5460	131,6815	68,9956
2.	C-6580	6,0940	6,3647	118,4460	66,6521
3.	C-8299	6,7932	7,0380	164,0643	69,2830
4.	C-8295	6,8979	7,1670	171,7614	68,2960
5.	C-8296	6,5945	6,9067	150,0776	65,8134

The contact surface of the seed is determined by the following expression [8]:

$$C_{ch} = \frac{A_f - A_t}{A_f} \cdot 100, \qquad (6)$$

Where: $A_f -$ flat surface of the seed, $A_t -$ The cross-sectional area is determined using the following expressions.

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A_f − flat surface of the seed, $A_f = \frac{\pi}{4}(l_{ch} \cdot b_{ch})$;
A_t − cross-sectional area, $A_t = \frac{\pi}{4}(b_{ch} \cdot h_{ch})$.

The calculation of the surface area of the seed is carried out by the following expression [6]:

$$A_{ch} = \pi D_g^2. \tag{7}$$

Numerical values of contact surfaces and surface areas of the seed samples under study are presented in Table 4. Also, when determining the average seed mass, 1000 undamaged seeds were taken and weighed using a digital scale with an accuracy of 0.0001 grams, and the average mass of one seed was determined.

Table.4

№	Sort of seeds	A_f, mm^2	A_t, mm^2	C_{ch}, mm^2	A_{ch}, mm^2	g
1.	C-6575	37,6591	21,5871	42,6776	125,1454	0,1
2.	C-6580	35,6765	19,4312	45,5350	116,6096	0,0985
3.	C-8299	43,4876	25,0990	42,2847	127,1995	0,1148
4.	C-8295	57,5801	25,5091	55,6980	149,4044	0,124
5.	C-8296	41,6882	22,4667	46,1077	136,5505	0,1137

Volumetric and real density of the seed. Bulk density of seed $-\rho_{ch}$ $500\ ml$ It is defined in a container with a volume of a cylinder. Cotton seeds are filled into a measuring cylinder, and then their weight is determined (Fig. 4).

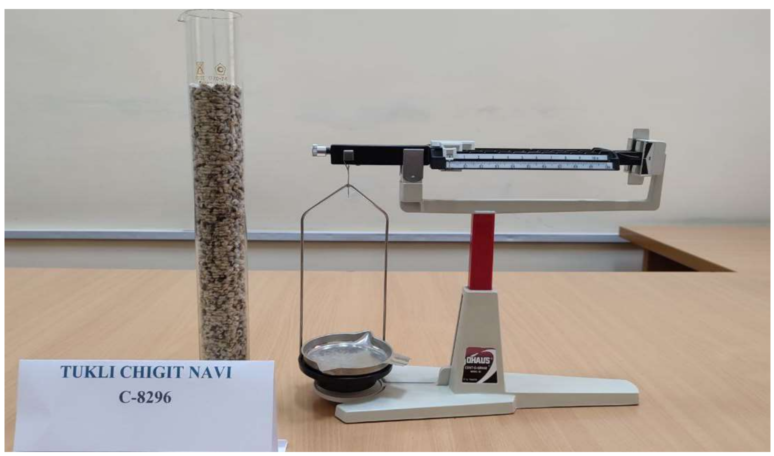

Figure 4. Determination of seed density

Determination of weight OHAUS GENT-0-GRAM is carried out on a branded scale. In this case, 500 ml. if we define the weight of the seed in the volume as W_{500ml} and if we define the volume taking into account the spaces between the seeds as V_{500ml}, then the following expression is used to determine the volume density of cotton seeds [5]:

$$\rho_h = \frac{W_{5000\ ml.}}{V_{5000\ ml.}} \tag{8}$$

The device for determining the true density of the seed is 250 ml. consists of a container and high-precision digital scales. 100 ml per measuring cylinder. toluene liquid is poured. Then seeds of known weight are placed in the cylinder container. The level of the toluene liquid in the cylinder rises from its initial value. If we define V_{ch} obtained as a result of the level change in the measuring cylinder, the actual density of the seed is determined by the following expression:

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$$\rho_x = \frac{W_{ch}}{V_{ch}} \tag{9}$$

The porosity index of the seed is determined by the following expression [5]:

$$P_f = (1 - \frac{p_h}{\rho_x}) \cdot 100 \tag{10}$$

The values of bulk density, true density and porosity obtained using expressions (8), (9) and (10) are presented in Table 5.

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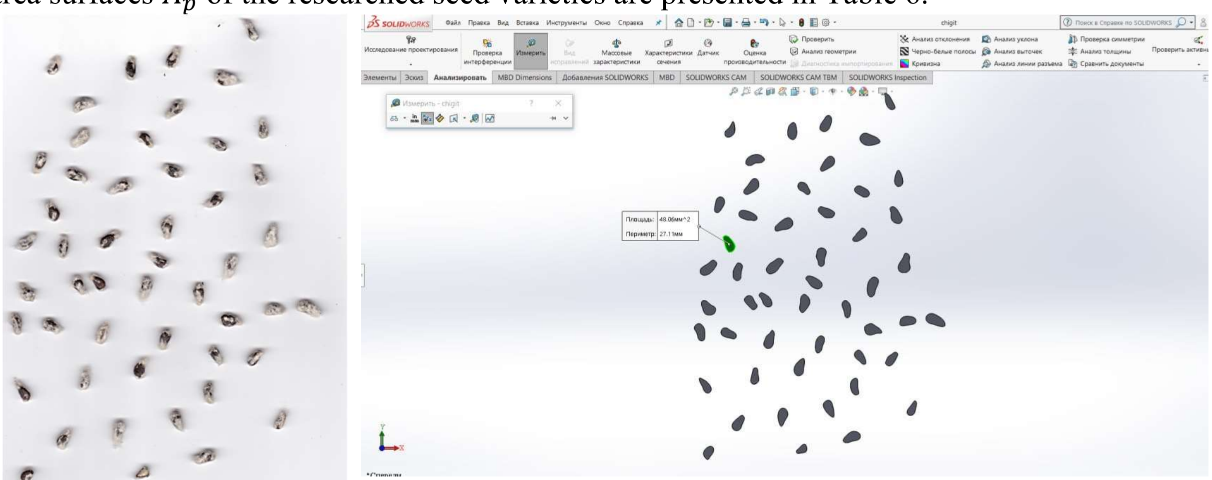
№	Sort of seeds	$\rho_h, \frac{g}{sm^3}$	$\rho_x, \quad \frac{g}{sm^3}$	Porosity %
1.	C-6575	0,4641	1,0956	57,6396
2.	C-6580	0,4552	1,0676	57,3623
3.	C-8299	0,4544	1,0485	55,2797
4.	C-8295	0,4955	1,1080	55,2797
5.	C-8296	0,4788	1,1060	56,7088

To determine the projected area A_p of the hairy seed, 50 seeds were randomly taken, and the image of the hairy seed in its natural flat state was scanned using a scanner (Fig. 5, a). The resulting image was exported to SolidWorks, keeping the scales (Fig. 5, b). The average values of the projected area surfaces A_p of the researched seed varieties are presented in Table 6.



a *B*

Figure 2.5. Determination of fuzzy seed projected area. a-scanner image, b-identification of fuzzy seed projected area in SolidWorks software

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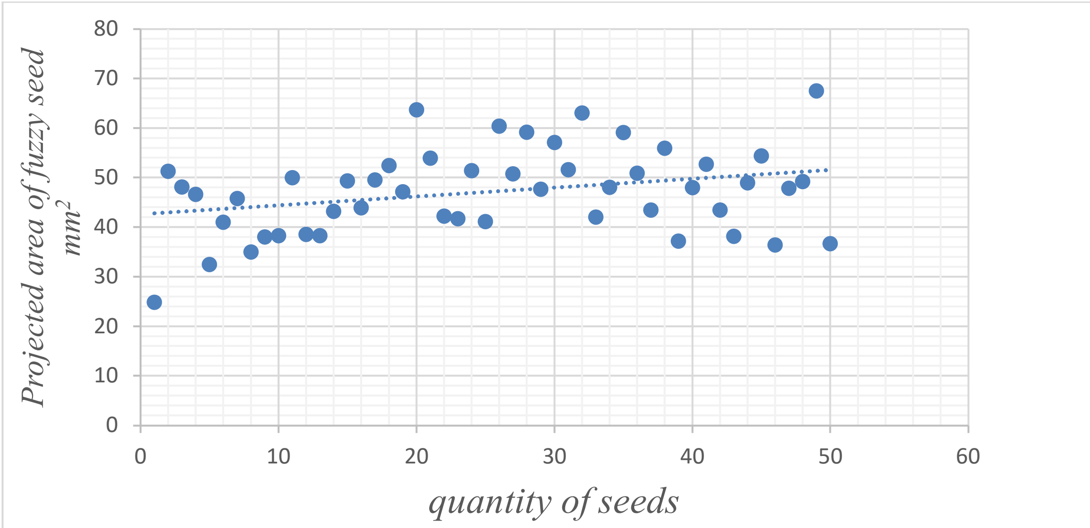

Figure 6. Projected area of 50 seeds taken at random

Table 6.

Sort of seeds	C-6575	C-6580	C-8299	C-8295	C-8296
Projected area, mm^2	47,1856	46,9645	47,2112	47,9496	47,4854

Mechanical properties of fuzzy cottonseed. The repose angle of the seed is an important factor in the design of seed processing and transportation machines. It is the value of this angle that is important in determining the angle of natural movement of the flow occurring in the hair seed rotary feeder. This angle is a necessary parameter in the design of the geometric shape of the hopper of the grain seed supply and the part of the funnel, as well as in the design of the working surfaces of the plates of the rotary feeder.

To determine the repose angle of the fuzzy seed, a cylindrical container with a diameter of D=80 mm and a height of H=200 mm and a wooden table with a flat surface are needed. The cylindrical container is freely filled with seed and slowly poured vertically on the table (Fig. 7). Then, the height and average diameter of the formed seed pile was determined.

The repose angle is determined by the following expression:

$$\phi = tan^{-1}\left(\frac{2H}{D}\right) \tag{11}$$

Where: ϕ -repose angle, degree, H- vertical height of cotton seed, mm, D-circular disc diameter, mm.

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Figure 7. Determination of the fuzzy seed repose angle

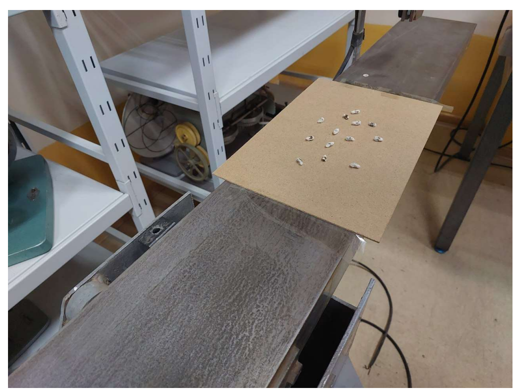
Values of equilibrium angles calculated using expression (8) in the researched varieties were determined (Table 7).

Table 7

Sort of seeds	C-6575	C-6580	C-8299	C-8295	C-8296
The average value of repose angle, *gradus*	48°20′	47°30′	46°10′	45°20′	45°50′

The coefficient of static friction was determined on the surface of three different materials: mild steel (Fig. 8, a), plywood (Fig. 8, b) and glass plate (Fig. 8, c) using the plane deviation method. An EPP laboratory device with an accuracy of 0.1 degrees was used to determine the friction angle. The experiment was carried out on a hammer-shaped steel plate and plywood and glass plates glued on it. The experiment was carried out several times.

A



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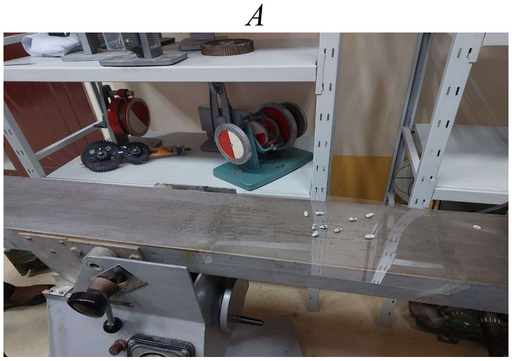

C

Figure 8. Determination of friction angles.
a- in mild steel;
b-plywood;
c-on a glass plate.

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The coefficient of friction was determined by the following expression:

$$\mu = tan\alpha \tag{12}$$

Where: m is the coefficient of static friction, α is the angle of deviation, in degrees.

Table 8 shows the values of the angle of deviation and the corresponding numerical values of the coefficient of friction for the researched fuzzy seed varieties.

Table 8

Sort of seeds	In mild steel		Plywood on the plate		On a glass plate	
	$\alpha_{o\prime rt}$	μ	$\alpha_{o\prime rt}$	μ	$\alpha_{o\prime rt}$	μ
C-6575	$18°10'$	0,3278	$19°10'$	0,3573	$12°20'$	0,2186
C-6580	$18°20'$	0,3313	$20°10'$	0,3669	$12°40'$	0,2247
C-8299	$19°10'$	0,3472	$19°20'$	0,3508	$13°30'$	0,2400
C-8295	$19°20'$	0,3507	$19°40'$	0,3574	$13°10'$	0,2336
C-8296	$19°20'$	0,3507	$19°20'$	0,3508	$14°10'$	0,2515

Rupture force and deformation ratio of fuzzy seed. The rupture force D_y of the seed means the force that causes partial or complete breakage (breakage) of the seed. The rupture force and ratio of deformation of the seeds are carried out using a digital Universal Material Tester. The limit value of the force exerted by this device is 0÷20kN and the accuracy level is 0.1N. 25 seed varieties were selected. The selected seeds were placed on a special plate in sequence according to the varieties, and the force was applied slowly until cracks appeared on its surface. The indicators were recorded. The value of the deformation coefficient at the crack limit was determined by the following expression [10-13:]

$$D_y = \frac{y}{d} \cdot 100\%, \tag{13}$$

Where: y −is the size of the seed at the crack boundary, the actual size of the seed before cracking.

Table 9 shows the rupture force and deformation ratio values for the seeds under study.

Table 9.

Sort of seeds	Rupture force, N	Ratio of deformation
C-6575	60,20	4,20
C-6580	62,10	4,40
C-8299	61,50	4,30
C-8295	58,80	4,00
C-8296	63,60	4,70

Result and discussion: The following can be concluded from the analysis of the results of the conducted experimental research:

During the production of studied seed sorts, 10.1369% in the C-6575 sort, 9.8955% in the C-8220 sort, 9.0862% in the C-8299 sort, and 8.2512% in the C-8295 sort. It is 9.8219% in C-8296 sort. This means that when determining the parameters of the rotary feeder, the moisture content of the seed should be taken as 9.44%.

The average length of a fuzzy seed is 9.65 mm, width is 5.37 mm, thickness value is 5.40 mm, average geometric diameter is 6.54 mm, average arithmetic diameter is 6.8 mm. Also; The volume of the fuzzy seed was 147.2 mm^3, sphericity 67.80, surface 43.22 mm^2, transverse surface 22.82 mm^2, contact surface 46.46 mm^2, surface area 131 mm^2.

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It was found that the average mass of one seed in the researched seed varieties is 0.1102 g, bulk density is 0.4696 g/cm^3, true density is 1.086 g/cm^3, porosity is 56.45%, projected area is 47.35 mm^2;

Average values of the balance angle of fuzzy seeds: 48°20' in C-6575 sort, 47°30' in C-8220 sort, 46°10' in C-8299 sort, 45°20' in C-8295 sort. It is 45°50' in C-8296 sort. It is the value of this indicator that is important for determining the design of the hopper of the rotary feeder. The average value of the repose angle is 46°40'. The ratio of static friction for the investigated seeds was 0.34 in mild steel, 0.36 in plywood and 0.23 in glass. Also, the average rupture force of fuzzy seeds was 61.24 N, and the average value of the deformation ratio was 4.32%.

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