

IMPROVING SOYBEAN GRAIN QUALITY

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The article presents a study of the quality of soybean varieties of different harvest dates, which often differs in its quality indicators. In order to improve this quality, it is advisable to fractionate seed according to different properties. The object of the study was the process of formation of soybean seed quality during its fractioning. By means of seed fractioning it is possible to prevent self-sorting of seed during movement and shaking, and as a result of effective cleaning, to improve its quality by separating grain with higher protein content, which will increase production efficiency and improve feed quality.

Key words: soybean, seed, quality, study, fractioning, quickly ripening variety, late-ripening variety.

Introduction. Today, soybean is a strategic crop for Ukraine grain exports of which are over 1 million tons per year. Unlike other market-oriented crops, soybean helps to improve soil fertility, increase crop yields within crop rotation. In addition, soybean has universal use and play an important role in improving the economic efficiency of production (Hlupak 2013; Kostetska, Herasymchuk 2022).

Soybean meal is a by-product of soybean oil extraction. During the processing of 1 ton of soybean seeds 7.5–8.0 soybean meals are collected. It contains less fiber and is better taken up than sunflower. 1 kg of soybean meal contains 1.21 feed units, 361 g of digestible protein, 26.2 g of fat, 80 g of fiber, 36.4 g of lysine, 8.5 g of methionine, 5.2 g of tryptophan. It is well consumed by all species of animals. Heat treatment gives it a pleasant smell. Adding 10% of soybean meal to the feed formula has a positive effect in terms of balancing protein and amino acid composition. Soybean cattle cake is obtained during the mechanical extraction of oil (Fialkovska 2019).

Soybean cattle cake is a product obtained by pressing soybean seeds, which contains a large amount of protein (15–40 %). With this method of obtaining oil, a large amount of fat remains in the waste (7–11 %). Due to this, soybean cattle cake has a high nutritional and energy value. However, due to high fat content, the cake does not last long and quickly turns sour when the storage conditions are violated. Soybean cattle cake, like soybean meal, is a valuable animal feed. 1 kg of cake contains 1.19 feed units, 346 g of digestible protein, 43 g of fat, 72 g of fiber (Ryvak et al. 2021).

Soy milk is a sweet, tasty white cream drink with a light, pleasant smell. It is a dietary product that does not contain lactose and is easily absorbed by the human body. It is recommended for stomach ulcers, cholecystitis, diabetes and food allergies to dairy products of animal origin. The nutritional value of soy milk corresponds to cow milk – 1.5–2.0 % fat, so it can act as an alternative to it. In addition, soy milk is rich in protein, which contains eight essential amino acids and many trace elements



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(Kostetska, Herasymchuk 2021). It is used to make soy yogurts, tofu, milkshakes for athletes and other foods that are high in protein.

Relevance of the problem. Soybean is a valuable universal crop. Soybean is among the important fodder crops in our country. In terms of protein content (35...50 %), fat (13...26 %), as well as vitamins and certain acids, it takes one of the leading places among other legumes (Lopatkina 2018). Modern world trends, growing domestic demand for soybean have necessitated an increase in the production of this crop in Ukraine. Therefore, it will be advisable to address issues related to post-harvest treatment of soybean seeds.

Seeds entering the elevator often differ significantly in their quality. In order to increase it, it is advisable to fraction grain and seeds according to different properties (geometric dimensions, density, etc.).

Previous research. Soybean seeds are the world's main source of feed and food protein. Statistics show that its share in the gross harvest of legumes is about 78 %. At present, more than 300 types of soybean foods are produced in different countries of the world, which requires seeds with different morphological and biochemical characteristics. Therefore, a wide range of varieties is needed, the cultivation of which could meet the needs of processing industries (Sichkar et al. 2007).

Due to the high content of protein and fat, as well as increased hygroscopicity of seeds, soybean under adverse conditions (e.g., the presence of organic impurities, high humidity) spoils quickly. Even dry seeds heat up in the presence of impurities. Therefore, immediately after harvesting seeds should be cleaned as much as possible from unthreshed beans, immature broken and flattened seeds and in case of need to dry to a moisture content of 12–14 % (Lopatkina 2018).

Formulation of the purpose of the study. The purpose of the study is to explore the formation of soybean seed quality depending on the process of its fractioning.

To achieve this purpose, the following study objectives were set:

- to carry out technological assessment of soybean seeds of early and late varieties;
- establish the fractioning process and determine its impact on seed quality;
- develop recommendations for the use of soybean varieties.

Research methodology. The study was conducted in the educational and scientific laboratory “Evaluation of the quality of seeds and products of its processing” (Uspalenko, Kostetska 2020). Seed analysis was performed according to the methods described in the standards.

Soybean seeds were grown in the Right Bank Forest-Steppe. The soil of the experimental fields is typical – gray forest, medium loam. Weather conditions, in general and during spring–autumn vegetation in particular, were favorable for the formation of optimal soybean yields.

Sieves with round holes with a diameter of 6.0 mm, 5.5 mm, 5.0 mm, 4.5 mm, 4.0 mm, 4.25 mm, 4.0 mm, 3.37 mm, 3.5 mm, 3.25 mm, 2.5 mm, 2.0 mm, 1.0 mm, scales, divider, carving board, laboratory glasswear, ruler and caliper were used for the study.

The subject of the study is early soybean seeds (vegetation period – 105 days) and late varieties (vegetation period – 120 days).

The object of the study is the processes of formation of soybean seed quality during its fractioning.

The procedure of the study:

1. Sampling. The weight of the sample for experiments is 2000 g (State standard 13586.3-83; SSU 3355-96).
2. Cleaning of soybean seeds from large garbage through a sieve with a diameter of 3 mm.
3. Physico-mechanical parameters of soybean seeds.
4. Determination of moisture in a mixture of one variety.
5. Determination of the mass fraction of protein, fat in a mixture of one variety.
6. Determination of the dockage of soybean mixtures of early and late varieties.
7. Determination of the mass of 1000 fillings in a mixture of early and late varieties of soybean.
8. Determination of GMO of soybean seeds of early and late varieties.
9. After determining the indicators of mixtures of early and late varieties, we carry out fractioning. With the help of sieves with round diameters of 6.0 mm, 5.5 mm, 5.0 mm, 4.5 mm, 4.0 mm, 4.25 mm, 4.0 mm, 3.37 mm, 3.5 mm, 3.25 mm, 2.5 mm, 2.0 mm, 1.0 mm. Then combined by fractions and re-analyzed by indicators: moisture, protein, fat, dockage, impurity content, weight of 1000 seeds, volume, density.
10. Analysis of the results obtained.

The following indicators were determined during the study:

- Physico-mechanical characteristics of soybean seeds (thickness, length, width, sphericity, volume, outer surface area, density);
- Fractional composition;
- Qualitative indicators of soybean seeds (physical: humidity, weight of 1000 seeds, dockage, size and uniformity; chemical: protein, fat, fiber, ash, GMO; organoleptic indicators);
- Soy milk content.

The experiments were guided by the methodology of the following standards:

1. Sampling – State standard 10852; SSU 3355.
2. Determination of seed smell and color – State standard 27988.
3. Determination of infection – State standard 10853; SSU ISO 6639-1; SSU ISO 6639-2; SSU ISO 6639-3; SSU ISO 6639-4.
4. Determination of dockage – State standard 10854; State standard 30483.
5. Determination of the mass fraction of protein – State standard 10846.
6. Determination of the mass fraction of oil – State standard 10857.
7. Ash content was determined according to State standard 28418-89.
8. Crude fiber content – according to SSU ISO 6865:2004.
9. Determination of the mass of 1000 seeds – State standard 10842-89.
10. Determination of seed moisture – State standard 10856; State standard 29143 (ISO 712–85); State standard 29144 (ISO 711–85); SSU 4117.
11. Soybeans. Specifications – SSU 4964:2008.

Methods for determining GMO. It is important that all equipment is thoroughly cleaned before use. To do this, a mechanical heel recovery is done as much as possible, and then the equipment and glasswear are wiped with a napkin (cotton swab) soaked in alcohol. The equipment must be dried or wiped with a napkin. To take a sample, a divider, a carving board, and blades were thoroughly cleaned and wiped. Selected samples of soybean seeds were sifted through a prepared sieve, removing impurities. 100 seeds were counted from the purified sample and their weight was determined

(M_{100}). The average weight of one seed divided by 100 was determined and the weight of the sample (M_n) for the analysis were determined by the formula:

$$M_n = \left(\frac{M_{100}}{100} \right) \times 1000, \text{ g} \quad (1)$$

where 1000 is the required number of seeds for the analysis.

The required volume of water (V_v) for extraction was calculated by the formula:

$$V_v = M_n \times 6, \text{ ml} \quad (2)$$

Covered with the lead glasswear was stirred vigorously for 20–30 sec. the resulting suspension should be of a “tight” consistency, but when settling for a short time (up to 1 min), free liquid should be formed, and the sediment should not have whole grains.

After sedimentation of plant matter, the required volume of extract (without matter) 0.5–1.2 cm³ was collected by micropipette and transferred to a microtube with a volume of 1.5 cm³. The test strip was placed for 5 min. in a disposable microtube with the extract to the specified label. Two lines on the test strip indicate positive result for GMO.

Results of the research.

Physico-mechanical characteristics of soybean seeds. Soybean seeds are spherical or oval in shape. For effective cleaning, drying, storage and processing of seeds, it is important to know the linear dimensions and physical and mechanical characteristics that are characteristic of both the crop and the variety. The sizes of soybean seeds are within the following limits: length – 5.2...8.2 mm, width – 4.6...6.7 mm, thickness – 3.5...5.5 mm.

To determine the geometric parameters of soybean seeds, 10 grains of one type of the studied seeds were taken and, using a caliper and a ruler, the length, width and thickness were measured.

According to the established geometric averages of the seeds, the volume, the area of the outer surface of the seeds, and the sphericity were calculated.

The volume of seed is determined by the formula:

$$V = k \times a \times b \times l, \text{ mm}^3 \quad (3)$$

where: a , b , l – are width, thickness and length of grain; surface k – research coefficient, for the grain of soybean $k=0,56$.

External surface area of seed of soy is determined by the formula:

$$F = 0.35 \times (a+b+l)^2, \text{ mm}^2 \quad (4)$$

Peculiarity of grain form is evaluated by its sphericity, which is the ratio of external surface area equivalent grain bullet (F_{sh}) for up to actual grain area (F):

$$\psi = \frac{F_{sh}}{F} \quad (5)$$

where:

$$F_{sh} = 4 \times \pi \times r^2 \quad (6)$$

$$r = 0.62 \times \sqrt[3]{V} \quad (7)$$

As a result of measuring the geometric characteristics of the studied soybean seeds, it was found that the seeds of an early variety are distinguished by large linear values. So, the length of the seeds was in the range from 5.0 to 7.0 mm, the width was

from 4.0 to 7.0, and the thickness was from 2.0 to 4.0 with average values of 6.0, 4.6, respectively and 3.1 mm. In turn, late-grade soybean grain was inferior in terms of their average linear length, width and thickness by 8, 9 and 32%, respectively.

According to formula 3, the volume of early grade soybeans was determined:

$$V = 0.56 \times 6.0 \times 4.6 \times 3.1 = 47.91 \text{ mm}^3$$

The external surface area of early soybean seeds was determined by formula 4:

$$F = 0.35 \times (4.6 + 3.1 + 6.0)^2 = 65.69 \text{ mm}^2$$

The sphericity is determined by formula 5. First, by determining the outer surface area of the equivalent grain ball using formulas 7 and 6:

$$r = 0.62 \times \sqrt[3]{47.91} = 2.25$$

$$F_{sh} = 4 \times \pi \times 2.25^2 = 63.72 \text{ mm}^2$$

Therefore, according to formula 5, the sphericity of early soybean grains:

$$\psi = \frac{63.72}{65.69} = 0.97$$

According to formula 3, the volume of late soybean seeds was determined:

$$V = 0.56 \times 5.5 \times 4.2 \times 2.05 = 26.52 \text{ mm}^3$$

The external surface area of late soybean seeds was determined by formula 4:

$$F = 0.35 \times (4.2 + 2.05 + 5.5)^2 = 48.32 \text{ mm}^2$$

The sphericity of late soybean seeds was determined by formula 5. The area of the outer surface of the ball of equivalent seeds was determined by formulas 7 and 6:

$$r = 0.62 \times \sqrt[3]{26.52} = 1.85$$

$$F_{sh} = 4 \times \pi \times 1.85^2 = 42.96 \text{ mm}^2$$

Therefore, according to formula 5, the sphericity of late soybean seeds is:

$$\psi = \frac{42.96}{48.32} = 0.89$$

A comparative assessment of the physical and mechanical properties of soybean seeds of early and late varieties is given in Table 1.

Table 1

Comparative evaluation of physical and mechanical properties of soybean seeds
(average for 2019–2020)

Experience	Linear dimensions, mm			Volume V, mm ³	Sphericity Ψ	External surface area F, mm ²
	Length l, mm	Width a, mm	Thickness b, mm			
Early variety	6.0	4.6	3.1	47.91	0.97	65.69
Late variety	5.5	4.2	2.1	26.52	0.89	48.32
According to literature sources*	5.2–8.2	4.6–6.7	3.5–5.5	50–85	0.92–0.95	60–95
	5.5	4.2	2.4	50.00	0.90	60.00

* – above the line – borders; under the line – average values according to literature sources (Hlupak 2013; Kostetska, Herasymchuk 2022; Fialkovska 2019; Ryvak et al. 2021; Lopatkina 2018).

As a result of the calculations, it was found that in terms of the sphericity and the area of the outer surface of the grain of the early variety, the average values of the literature sources prevail, while the late variety does not reach the lower limit of the literature data. The volume of grains of both early and late varieties is distinguished by inferior literary values.

Therefore, according to Table 1 it can be concluded that early soybean grain has a more rounded shape and larger grain size compared to late soybean seeds. It is expected that early soybeans will also contain more protein and fat, which is effective in the production of feed.

Qualitative indicators of soybean seeds of different fractions. Fractioning – the process of dividing seed mass into more homogeneous fractions.

The method of sieve analysis was used to select sieves with a round hole with a hole diameter 6.0 mm, 5.5 mm, 5.0 mm, 4.5 mm, 4.0 mm, 4.25 mm, 4.0 mm, 3.37 mm, 3.5 mm, 3.25 mm, 2.5 mm, 2.0 mm, 1.0 mm. As a result of sieve control, the largest seed fractions were determined, according to which the seeds were separated for further fractional study.

Thus, the studied grain was divided into fractions by seed ladder with a hole diameter 6.0 mm; 4.5 mm; 4.0 mm; 3.5 mm, as well as the passage of the sieve with a diameter of 3.5 mm.

The results of soybean seed yield from selected sieves are shown in Fig. 1, 2.

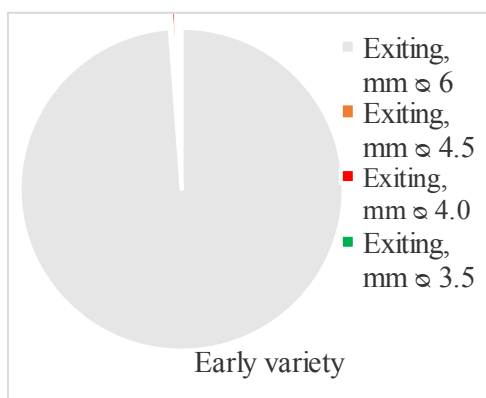


Fig. 1. Yield of grain fractions of early variety

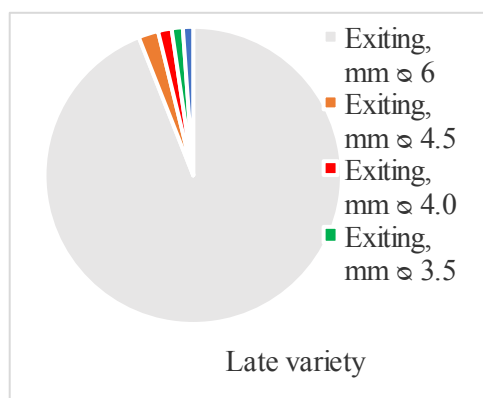


Fig. 2. Yield of grain fractions of late variety

Riddling \varnothing 6 mm was determined as the largest fraction, which was 96.94 % for the seeds of the early variety and 5 % less for the late variety. As the size of the sieve holes decreased, the amount of soybean seeds selected on it also decreased, with a slight quantitative advantage for late variety seeds. The results of this study characterize soybean grain as a large, fairly even grain and confirm the larger size of the early variety.

In further studies, we studied soybean seeds of different fractions for quality indicators: moisture, mass fraction of protein, mass fraction of fat, weight of 1000 seeds, the content of broken and immature seeds and organic impurities (Tables 2 and 3).

Table 2

Quality indicators of soybean seeds of early variety by fractions

Indicator	Exiting, mm				Passage ⊖ 3.5 mm	Mixture (control)	LSD ₀₅	
	⊖ 6.0	⊖ 4.5	⊖ 4.0	⊖ 3.5				
Moisture, %	9.1	-				16.87	8.9	0.44
Mass content of protein in terms of dry matter, %	35.9					0.90	0.20	
Mass content of oil, % of dry matter	23.2					0.96	2.98	
Mass content of fiber, % of dry matter	8.1					14.00	0.46	
Mass content of ash, % of dry matter	5.8					0.016	1.13	2.12
Impurity (organic)	0.016	1.13	2.12	3.06	16.87	0.90	0.20	
In oil impurity, %: - broken and crushed seeds	0.73	85.81	91.88	96.90	83.08	0.96	2.98	
- immature seeds	19.00	2.93	0.57	-	-	14.00	0.46	

Note. Indicators of soybean seed quality according to SSU 4964:2008: humidity – not more than 12 %; mass content of protein in terms of dry matter – not less than 35.0 %; mass content of oil in terms of dry matter – not less than 12.0 %; content of impurities and oil impurities (together) – not more than 10.0 %; in particular impurities – not more than 3.0 %; pest infestation – not allowed, except for tick infestation not higher than 1st degree.

Table 3

Quality indicators of soybean seeds of late variety by fractions

Indicator	Exiting, mm				Passage ⊖ 3.5 mm	Mixture (control)	LSD ₀₅	
	⊖ 6.0	⊖ 4.5	⊖ 4.0	⊖ 3.5				
Moisture, %	10.5	-				27.88	11.1	0.54
Mass content of protein in terms of dry matter, %	35.5					0.046	0.67	
Mass content of oil, % of dry matter	24.2					0.75	2.02	
Mass content of fiber, % of dry matter	6.0					0.20	0.53	
Mass content of ash, % of dry matter	4.9					0.026	1.97	39.19
Impurity (organic)	0.026	1.97	39.19	11.60	27.88	0.046	0.67	
In oil impurity, %: - broken and crushed seeds	0.70	88.03	-	55.23	57.62	0.75	2.02	
- immature seeds	0.19	9.19	9.28	30.42	12.64	0.20	0.53	

Note. Indicators of soybean seed quality according to SSU 4964:2008: humidity – not more than 12 %; mass content of protein in terms of dry matter – not less than 35.0 %; mass content of oil in terms of dry matter – not less than 12.0 %; content of impurities and oil impurities (together) – not more than 10.0 %; in particular impurities – not more than 3.0 %; pest infestation – not allowed, except for tick infestation not higher than 1st degree.

The results of the research have shown that the different fractions of seeds have homogeneous indicators, therefore, this distribution of seeds improves technological properties and facilitates the process of transportation and processing.

A comparative analysis of the chemical composition of early soybean seeds (Table 2) shows that exiting fraction of sieve with a diameter of 6.0 mm contains more protein than the control mixture which is not separated by fractions, at numerical values of 35.9 and 35.9 %, respectively.

It has been found that the fractions of soybean seeds from sieves with a diameter of 4.5, 4.0 and 3.5 mm are mainly oil impurities, which are represented for early and late varieties by 83–97 % and 55–88 %, respectively, broken and crushed seeds.

The early soybean variety with a exiting fraction with a diameter of 3.5 mm has the highest content of broken and crushed seeds, but there are no immature seeds. Whereas the seed fraction with a diameter of 3.5 mm has the most organic impurities – 16.87%.

In the late soybean variety, the highest content of broken and crushed seeds was found in the seed fraction with a diameter of 4.5 mm, whereas no broken and crushed seeds were found in the fractions found on the sieve with a diameter of 3.5 mm. Whereas the largest content of organic impurities was found in the fractions obtained on a sieve with a diameter of 4.0 mm and outsifting 3.5 mm, which was 27.88 and 39.19 %, respectively.

A comparative analysis of the chemical composition of soybean seeds of the late variety (Table 3) shows that exiting fraction of the sieve, with a hole diameter of 6.0 mm also contains more protein than the control mixture which is not separated by fractions, with numerical values 35.5 and 35.1 % respectively.

It was found that soybean seeds of the early variety had a higher protein content, but were inferior to the grains of the late variety in terms of fat content. In the soybean grain of the studied varieties, moisture content was determined from 8.9 to 11.1 %, the number of broken seeds and organic impurities – not more than 1.0 %, which does not exceed the permissible norms of the standard SSU 4964: 2008. At the same time, early soybean has a large number of immature seeds, which should be taken into account when storing them.

Thus, from the data in tables 2–4, it can be concluded that with the help of seed fractioning it is possible to separate grain with a higher protein content, which will increase production efficiency, improve the quality of feed and, obviously, reduce its cost. Also, fractioning is an effective way to purify seeds. Sorting seeds into fractions makes it possible to increase the efficiency of cleaning soybean seeds by fractions, which reduces the load on cleaning machines compared to cleaning it in the stream.

Evaluation of the nutritional value of soybean seeds. Before recommending soybean seeds for feed purposes, it is necessary to calculate its nutritional value (Tables 4, 5).

NFE are nitrogen-free extracts, the determination of which takes into account the content of protein, fats (oils), ash and fiber (formula 8):

$$NFE = 1000 - (P + F + A + F) \quad (8)$$

To formulate the values of P, F, A, F in grams per kg, it is necessary to multiply the values of their mass fractions (these Tables 2, 3) by 10.

Thus, soybean seeds have a high nutritional value, which is expressed in significant feed units, in particular, early soybeans are less nutritious than late seeds only by 3.35 % for 1.44 feed units. For comparison, the grain of soft wheat is characterized by an average of 1.20 feed units, corn – 1.33 feed units (Ryvak et al.

2021). Thus, it can be concluded that the soybean seeds of the studied varieties are highly nutritious animal feed.

Table 4

Calculation of the total nutritional value of 1 kg of soybean seeds of the early variety

Nutritional substance	Fraction	Protein (P)	Fat (F)	Fiber (F)	NFE
Content of indicators, g	Exiting \varnothing 6.0 mm	359	232	81	270
	Mixture (control)	355	235	90	261
Digestibility ratio			0.70	0.90	0.33
Content of digestible nutrients, g	Exiting \varnothing 6.0 mm	251.3	208.8	26.73	248.40
	Mixture (control)	248.5	211.5	29.70	240.12
Performance indicators, g			1.57	3.18	1.67
Total productive effect, g feed unit	Exiting \varnothing 6.0 mm	394.54	663.98	44.64	414.83
	Mixture (control)	390.14	672.57	49.60	401.00
The amount of productive effect, g feed unit	Exiting \varnothing 6.0 mm	1517.99			
	Mixture (control)	1513.31			
Coefficient of completeness			0.95		
Nutrition, g feed unit	Exiting \varnothing 6.0 mm	1.44			
	Mixture (control)	1.44			

Table 5

Calculation of the total nutritional value of 1 kg of soybean seeds of the late variety

Nutritional substance	Fraction	Protein (P)	Fat (F)	Fiber (F)	NFE
Content of indicators, g	Exiting \varnothing 6.0 mm	355	242	60	294
	Mixture (control)	351	246	67	284
Digestibility ratio			0.90	0.33	0.92
Content of digestible nutrients, g	Exiting \varnothing 6.0 mm	248.50	217.80	19.80	270.48
	Mixture (control)	245.70	221.40	22.11	261.28
Performance indicators, g			3.18	1.67	1.67
Total productive effect, g feed unit	Exiting \varnothing 6.0 mm	390.15	692.60	33.07	451.70
	Mixture (control)	385.75	704.05	36.92	436.34
The amount of productive effect, g feed unit	Exiting \varnothing 6.0 mm	1567.52			
	Mixture (control)	1563.06			
Coefficient of completeness			0.95		
Nutrition, g feed unit	Exiting \varnothing 6.0 mm	1.49			
	Mixture (control)	1.48			

Determination of the density of different fractions of soybean seeds. Since early soybean seeds were characterized by a high content of underdeveloped seeds, our studies were related to the study of their density. Density indicates the degree of maturity and fullness of the seeds. Mature and full seeds have a higher density than unripe ones. The difference in seed density and impurities is used in seed sorting and cleaning. As a result of different density in the grain, self-sorting occurs when moving and shaking. This can be taken into account when cleaning seeds at the elevator.

The physical density of seeds is closely related to nature. The greater the density, the greater the nature (Kostetska, Herasymchuk 2022; Fialkovska 2019; Ryvak et al. 2021). Hence, the grain density is determined by the formula 9:

$$\rho = \frac{m}{V}, \text{ g/cm}^3 \quad (9)$$

where: m – grain mass, g; v – grain volume, cm^3

As a result of measuring the geometric characteristics of the studied soybean seeds, it was found that the seeds of an early variety are distinguished by large linear values. Thus, the length of the seeds ranged from 5.0 to 7.0 mm, the width, from 4.0 to 7.0, and the thickness, from 2.0 to 4.0, with average values of 6.0, 4.6, and 3.1 mm, respectively. In turn, late-grade soybean grain was inferior in terms of their average linear length, width, and thickness by 8.9 and 32%, respectively.

From formula 4, the volume of early grade soybeans was determined to be 47.91 mm^3 and the volume of seeds of late grade soybeans was 26.52 mm^3 (Table 1).

The mass of 1000 seeds was determined to State standard 10842-89.

where: N – number of grains; $M_{1000 \text{ seeds}}$ – mass of 1000 seeds.

For calculations, the following characteristics of soybean seeds were taken:

a) Linear average dimensions of the studied early soybean seeds in a mixture without fractionation: length 6.0 mm, width 4.6 mm, thickness 3.1 mm, volume 47.91 mm^3 , weight of 1000 seeds 147.0 g.

b) Linear average dimensions of the studied late-grade soybean seeds in a mixture without fractionation: length 5.5 mm, width 4.2 mm, thickness 2.1 mm, volume 26.52 mm^3 , weight of 1000 seeds 127.3 g.

The mass of the grain was determined by the formula 10:

$$m = \frac{M_{1000 \text{ seeds}}}{N}, \text{ g} \quad (10)$$

$$1) \frac{147.0}{1000} = 0.147 \text{ g}; 2) \frac{127.3}{1000} = 0.1273 \text{ g}$$

Seed density was set by the formula 9:

$$1) \frac{0.147}{47.91} = 3.0 \text{ g/cm}^3; 2) \frac{0.1273}{26.52} = 4.8 \text{ g/cm}^3$$

Based on formulas 9 and 10, we find the density from formula 11:

$$\rho = \frac{M_{1000 \text{ seeds}}}{NV}, \text{ g/cm}^3 \quad (11)$$

As a result of calculations, it was found that seeds of early variety soybeans have lower density values compared to seeds of late variety (Fig. 3, 4 and 5), which confirms the content of immature seeds in early variety soybeans. It was determined that the seeds of the early variety showed a decrease in density in the sieve fraction \varnothing 4.5 mm. Obviously, unripe seeds were mainly in this fraction. In turn, both varieties showed a trend towards an increase in density value with decreasing seed size.

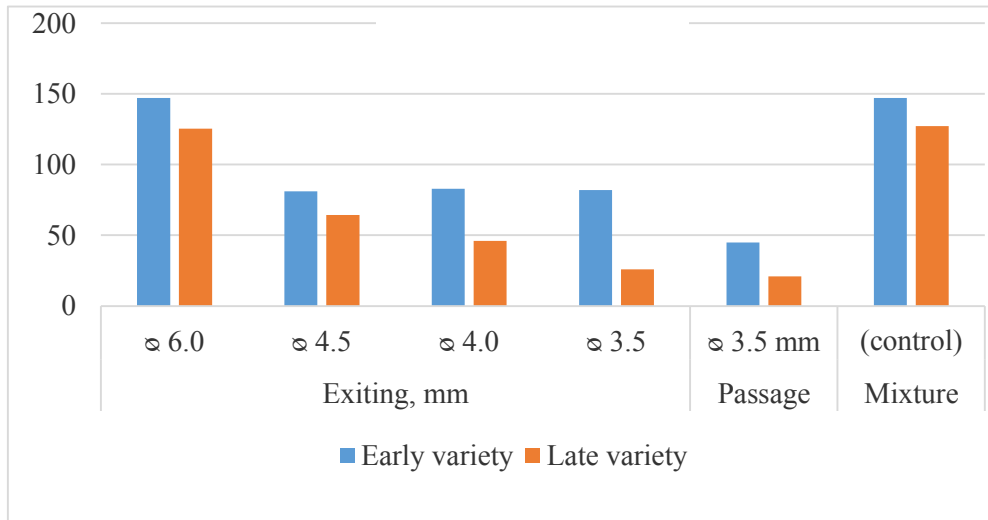


Fig. 3. The mass of 1000 seeds, g

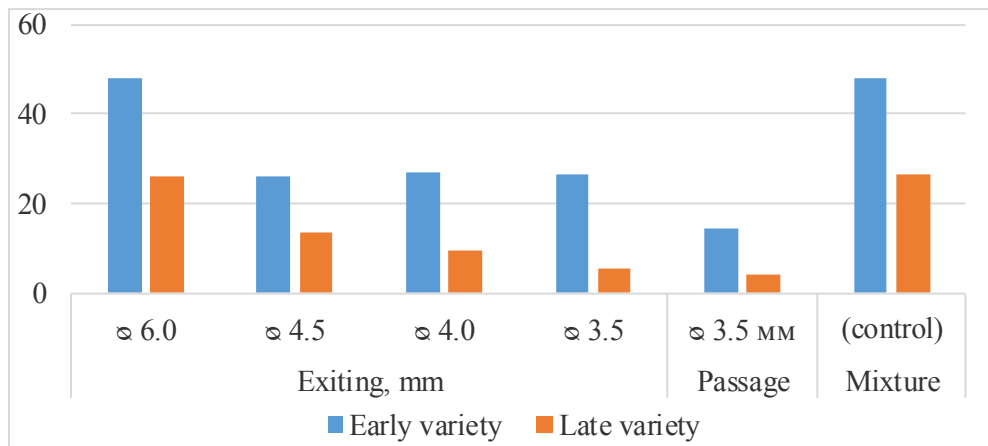


Fig. 4. The grain volume, mm³

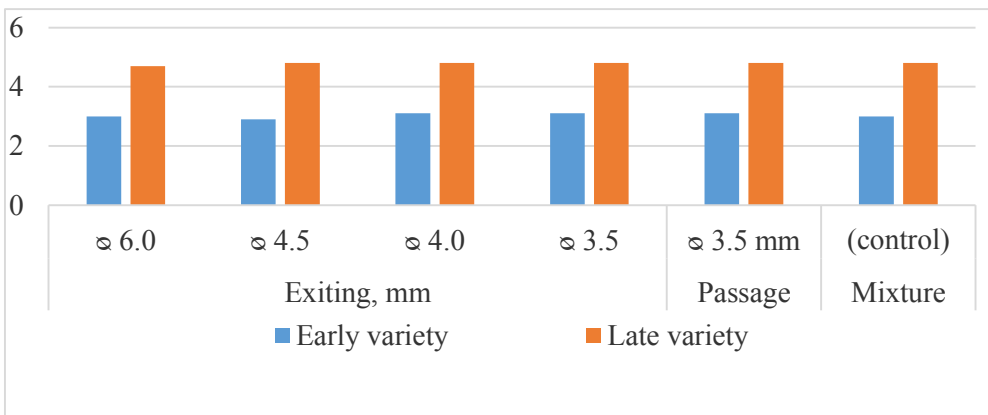


Fig. 5. The grain density, g/cm³

Therefore, it can be concluded that with the help of fractionation, self-sorting of seeds during movement and shaking can be prevented and, as a result of effective cleaning, the quality of seeds can be improved.

Study of soybean seeds for soy milk content. Soy milk is obtained from soybean soaked in water, crushed and steamed. Soybean was preparatory soaked for 8–10 hours. Then 1 kg of soaked soybean were picked from coating and debris. Then they were grounded in a laboratory grinder. Then the crushed soybean was diluted in distilled water in a ratio of 1:2. The mixture was stirred well, brought to a boil, boiled for 10 minutes, cooled and filtered through a sieve with a diameter of 1.0 mm. The yield of soy milk was calculated by the mass of the obtained extract.

The results of the study are shown in Figure 6.

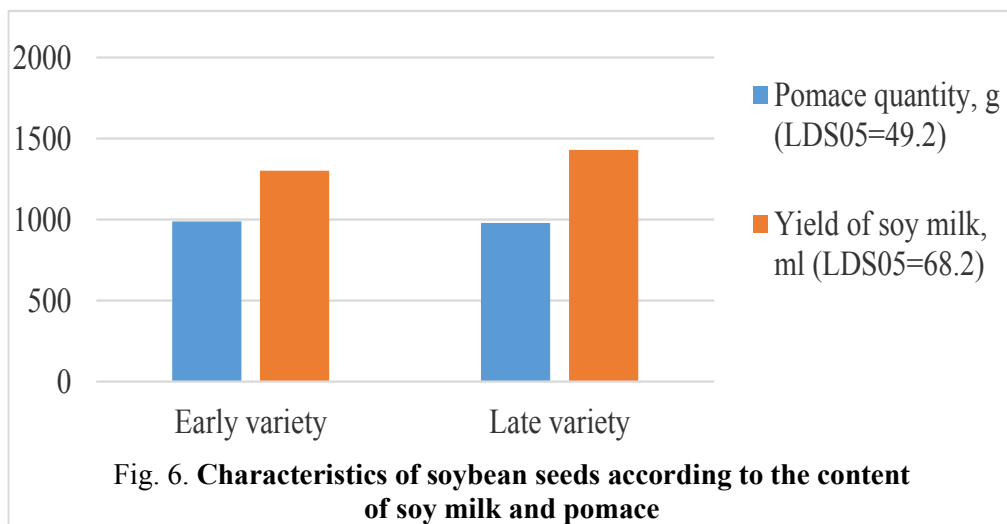


Fig. 6. Characteristics of soybean seeds according to the content of soy milk and pomace

Thus, based on the results of the study, it can be concluded that early soybean seeds can be recommended for the production of feed, while late soybean seeds – for the production of soy milk.

Study of soybean seeds on GMO. Sampling was performed with a sterile divider. The test portion (100 g) was purified from all impurities using a sieve with a round hole with a diameter of 3 mm. To determine the weight of the soybean portion on GMO, 100 g of soybean seeds of the early variety and 100 g of soybean of the late variety were taken and by formula 1 it was determined:

$$1) \frac{14.7}{100} \times 1000 = 147 \text{ g}; \quad 2) \frac{12.55}{100} \times 1000 = 125.5 \text{ g}$$

A portion of seeds was crushed in a grinder for 30 seconds (to a fine fraction). Then extraction with distilled water was performed. The required volume of water for extraction was calculated by formula 2: 1) $147 \times 6 = 882 \text{ ml}$; 2) $125.5 \times 6 = 753 \text{ ml}$

After mixing the crushed soybean seeds with distilled water and after setting the plant residues, 0.5 cm³ of extract were collected with a micropipette in a 1.5 cm³ microtube, where the test strip was placed for 5 minutes.

The study showed that the late soybean contains GMO and early soybean does not contain GMO.

Conclusions

Based on the analytical review, including the technological process of feed production, it can be concluded that the seed entering the elevator differ in quality. So to improve its quality it is necessary to fraction it.

As a result of experimental study, the following **conclusions** were made:

1. Early soybean seed has a more rounded shape, larger grain size, higher protein content compared to late soybean seed, which is effective in the production of feed.
2. Early soybean seed has lower density values than late soybean seed, which confirms the content of immature seeds in early soybean.
3. By means of seed fractioning it is possible to prevent self-sorting of seeds during movement and shaking, and as a result of effective cleaning, to improve its quality by separating grain with higher protein content, which will increase production efficiency and improve feed quality.
4. Late soybean contains GMO and early soybean does not contain GMO.
5. Taking into account that the soybean of early varieties is characterized by high protein content and gives a large amount of cattle cake, we can recommend it for the production of feed, while soybean of late varieties – for the production of soy milk.

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ПІДВИЩЕННЯ ЯКОСТІ НАСІННЯ СОЇ

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Наведено результати досліджень якості насіння сої сортів різних строків збирання, що часто відрізняється своїми якісними показниками. Задля підвищення такої якості доцільно проводити фракціонування насіння за різними властивостями (геометричні розміри, густина ін.). Мета дослідження – вивчити питання формування якості насіння сої залежно від процесу його фракціонування. Для досягнення мети були поставлені наступні завдання дослідження: провести технологічну оцінку насіння сої раннього та пізнього сортів; встановити процес фракціонування та визначити його вплив на якість насіння; розробити рекомендації щодо використання сортів сої. Предметом досліджень було насіння сої раннього сорту (вегетаційний період – 105 днів) та пізнього сорту (вегетаційний період – 120 днів). Об'єкт дослідження – це процеси формування якості насіння сої під час його фракціонування. Дослідження проводилося згідно методик описаних у стандартах в навчально-науковій лабораторії «Оцінювання якості насіння і продуктів його перероблення» Уманського НУС. Насіння сої вирощено в умовах Правобережного Лісостепу. Ґрунт дослідних полів типовий – сірий лісовий, середньо-суглинковий. Погодні умови, у цілому та весняно-осінньої вегетації зокрема, були сприятливими для формування оптимальних урожаїв сої. Для дослідження використовували сита з круглими отворами діаметром: 6,0 мм, 5,5 мм, 5,0 мм, 4,5 мм, 4,0 мм, 4,25 мм, 4,0 мм, 3,37 мм, 3,5 мм, 3,25 мм, 2,5 мм, 2,0 мм, 1,0 мм, ваги, дільник, розбірна дошка, лабораторний посуд, лінійка, штангельциркуль. За допомогою фракціонування насіння можна запобігти самосортуванню насіння під час переміщенні та струшуванні, та в результаті ефективного очищення, покращити його якість, відокремивши зерно з більшим вмістом білка. Враховуючи те, що зерно сої раннього сорту характеризується високим вмістом білка, дає велику кількість жмиху, ми можемо рекомендувати його для виготовлення комбікормів, тоді як зерно сої пізнього сорту – для виготовлення соєвого молока.

Ключові слова: соя, насіння, якість, дослідження, фракціонування, ранньостиглий сорт, пізньостиглий сорт.