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Resource-saving method of extracting cucumber and melon seeds

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Abstract. The production of vegetable and melon crops is one of the most labour-intensive branches of agricultural production. Production volumes depend not only on growing conditions, but also on the quality of seed material. A resource-saving method of extracting cucumber and melon seeds and a separator that allows its implementation are presented. The design feature of the separator is a combination of vibration and inertial modes. The use of a separator, which has a combination of the mentioned modes in the technological process, allows to significantly improve the quality of separation of seeds from the peel and pulp. Thus, at the next stage, when washing the seeds, it is possible to reduce the amount of water, using the technology of a complete closed cycle of cleaning for reuse. The scheme of the technological process of cucumber and melon seed separation, which is used to implement a resource-saving method, is presented. The main factors and optimization criteria were determined, according to which the quality assessment of the technological process of cucumber and melon seeds separation was carried out using the proposed constructive solution. The ranges of the optimal combination of independent factors are determined. Using a resource-saving method of extracting cucumber and melon seeds allows to significantly reduce water consumption when washing seeds and achieve an improvement in the quality of the technological process.

1. Introduction

The production of seed material of melon and vegetable crops is one of the most important problems that have arisen in the field of processing agricultural products. In the southern part of Ukraine, there were specialized farms for the production of seeds of vegetable crops. The volume of this production of cucumber and melon seeds was significant and provided seed material to almost all farms of Ukraine. Thus, the development of seed production of vegetable and melon crops, such as cucumber and melon, will provide an opportunity to provide the economy of Ukraine with seed material. High-quality seed material is one of the conditions for increasing productivity and reducing the cost of cultivated products, and well-organized seed separation in farms increases the production crops by 20 ... 25%.

Enhancing the sustainability of the food system begins with boosting food production [1]. Moreover, it is crucial to offer the theoretical underpinnings of the corporate interaction management technique [2]. Practitioners interested in learning more about various water engineering models and approaches, as well as their real-world applications and case studies, can find valuable information in economy of water in technological processes [3]. There are presented and discussed is the evolution of the key accomplishments in water-saving engineering solutions, with a focus on the key technologies [4]. Ukraine is among the top producers and exporters of agricultural production in the world, and expanding production and the economy can both benefit from market integration between Ukraine and the EU [5–7]. For the environmentally friendly production of agricultural production, it is crucial to optimise the technological processes [8]. Farmers may decrease their carbon footprint, cut greenhouse gas emissions, and boost sustainable productivity through climate-smart agriculture [9]. Melon selection process, which prioritizes quality, plays an important role in obtaining a quality product. A technique that uses the relationship between parameters to provide descriptions and actions in determining melon quality is used to describe, extract, and share semantic information [10]. The possibility of short-wave near-infrared spectroscopy for fruit classification issues is examined in the research. When fruit categorization automation is needed, an LED-based device with 770 nm, 840 nm, 910 nm, and 960 nm range LEDs can be employed [11].

The production of seeds of vegetable and melon crops in Ukraine is carried out in the conditions of agricultural enterprises and farms. The obtained seeds of above mentioned crops today do not meet the needs of agriculture, and this leads to the need to purchase seed material. Separation of seeds is carried out mainly on separators of the mechanical type: inertial, rotary or roller. It has found limited use in the seed production of vegetable crops. Flotation separation is practically not used due to high water consumption and significant material capacity of technological equipment. Pneumoseparation is energy-intensive and time-consuming when converting separators from one culture to another. Inertial and rotary separators have approximately the same productivity and quality indicators of the technological process. The use of one or another type of rotary separators is related to the specifics of obtaining seeds of the crop, the volume of its production and the technical security of the farm.

Due to the lack of special equipment, machines not designed for this purpose are often used in labor-intensive seed production processes, which in turn leads to large product losses. The efficiency of production processes of seed separation and finishing is very low. The main reason for this situation is the lack of scientific research to substantiate the principle of action, structural parameters and kinematic modes of machines and their working bodies. Information is often contradictory. This state is largely due to the lack of generalizing theoretical and experimental studies of the processes of separation and finishing of seeds, which, accordingly, affected the development of machines and technological lines.

An analytical summary of all the components of the complete cycle of cultivation and processing was produced, ranging from a detailed investigation of the characteristics of melon cultivation to studies on enhancing technologies to produce high-quality seeds. Erniati et al. [12], for instance, investigated melanoculture and the ideal conditions for producing material of superior quality. The growing parameters received special attention in this study, which monitored plant age, leaf area, plant height, relative humidity, air temperature, and radiometric solar intensity to forecast these parameters for the next two days.

Research on growing melon and vegetable crops as well as useful methods for extracting seeds has received a lot of interest. To satisfy the demands of contemporary agriculture, high-quality vegetable and melon crop seeds are necessary to cut expenses and do away with the necessity to buy them from outside producers [13]. Wahyudi et al. [14] focused on yield estimation of novel hybrid watermelon cultivars. It has been demonstrated that producing melon seeds within an agricultural business can boost output and revenue for growers of the fruit. An essential part of a plant breeding programme is the examination and selection of seeds. Kale et al. [15] investigated the impact of the mechanical and technological characteristics of vegetable and melon seeds on the ensuing seed quality, whereas Fayzullaev et al. [16] showcased the creation of a machine for planting vegetable and melon crops. Tests have demonstrated that the created machine satisfies all performance requirements and carries out the designated technological procedure with reliability.

According to Tlevlessova et al. [17], the shift from large-scale farming to small-scale home growing has necessitated the introduction of cutting-edge scientific research and technology in order to produce high-quality seeds. The authors underlined that the shift in production from large agricultural operations to small private farms, which today account for over 90% of the total, is one of the major issues facing industrial melon seeds production. Simultaneously, small producers receive additional revenue from the transfer of output to the private sector, which could be their sole source of income. Private farms are more suited to the particulars of market interactions, as evidenced by the current state of affairs. A study was undertaken by Osuji et al. [18] to compare the processes of manual and mechanised seed separation for melon and vegetable crops. Using a press machine and a mechanical melon peeler, the seeds were peeled both manually and mechanically. It was determined how effective these devices were at extracting seeds. Out of all the automated procedures, the proposed design was the most productive. The cleaned seeds were assessed using technological and mechanical criteria. The results of the study demonstrated how important it is to select an appropriate variety, seed separator, and packing material in order to produce vegetable and melon seeds with optimal efficiency and quality. Kuchakorn et al.'s experiment from 2021 effectively separates ripe from unripe watermelons. The study focused on employing specialised equipment to determine fruit ripeness and if it was suitable for additional seed extraction [19]. The impact of native and germinated melon seeds on product quality is investigated in the paper [20].

Nascimento [21] pointed out that improving and preparing seeds can be a useful way to boost melon crops' survival rate. Particularly in cold climates, primed seeds perform better during germination. The author talks about a few factors of seed preparation and how they affect the germination and yield production of melon seeds [21]. Mazuela and Urrestarazu conducted experiments on improving the growing environment for vegetable crops in the context of studying the full cycle of vegetable and melon crops cultivation and seed production [22]. They noted that there is a need to increase the number of producers of vegetable and melon seeds. Getting hold of high-quality seeds contributes to higher yields, and grafting technology works wonders in lowering seed damage and yield losses. Lee et al. examined the topic of automating machines for cultivating vegetable crops [23]. The physical characteristics of vegetable crops have also been studied [24]. Thus, an essential component of the fields of food production and agricultural technology is the study of the physical characteristics of vegetable and melon crops and the methods used to measure them.

It is necessary to summarize the available experience in the development of machines for the complex mechanization of obtaining seeds of vegetable and melon crops, and on the basis of it to outline the main ways of developing and creating technological equipment. This will allow to increase the volume of production of seed material, will lead to a reduction of its losses in the process of production, storage and sale and ultimately will provide Ukraine with high-quality seeds. However, the creation of modern machines for the separation of seeds and technological lines that meet the requirements of modern production and belong to complex technical systems requires a deeper study of the interaction of working bodies with the processed product, the laws of the technological processes they perform, the dynamics and conditions of their operation. This task can be solved by conducting extensive theoretical and experimental studies of systematization and analysis of the achieved level of technical solutions. Thus, theoretical and experimental researches that allow to create modern, high-performance equipment for obtaining seeds of vegetable and melon crops are relevant and have an important national economic significance.

The aim of the article is to present the resource-saving method of extracting cucumber and melon seeds.

2. Methods

The methodology is based on the specific conditions for conducting experiments with the development and manufacture of the vegetable and melon seeds separator. To distinguish regular changes from random indicators, statistical methods of research and mathematical processing are applied [25]. For each experiment, 25..30 kg of crushed seed mass was selected, which was weighed, and the value of the selected weight was recorded in the log of laboratory and field observations. The main optimization criteria used to assess the quality of the technological process were: damaging of seeds (DS), purity of seeds (PS) and loss of seeds (LS). Their values must meet the following requirements:

- the amount of seed damaging should not exceed 5%;
- the value of seed purity should strive for the maximum level;
- losses should tend to the minimum value.

Before starting the experimental studies, the factors affecting the process were selected and the limits of their variation were indicated. In the initial stage of studying any object using the theory of experiment planning, it is necessary to conduct an a priory ranking of factors, which is performed by the method of expert evaluation (figure 1).

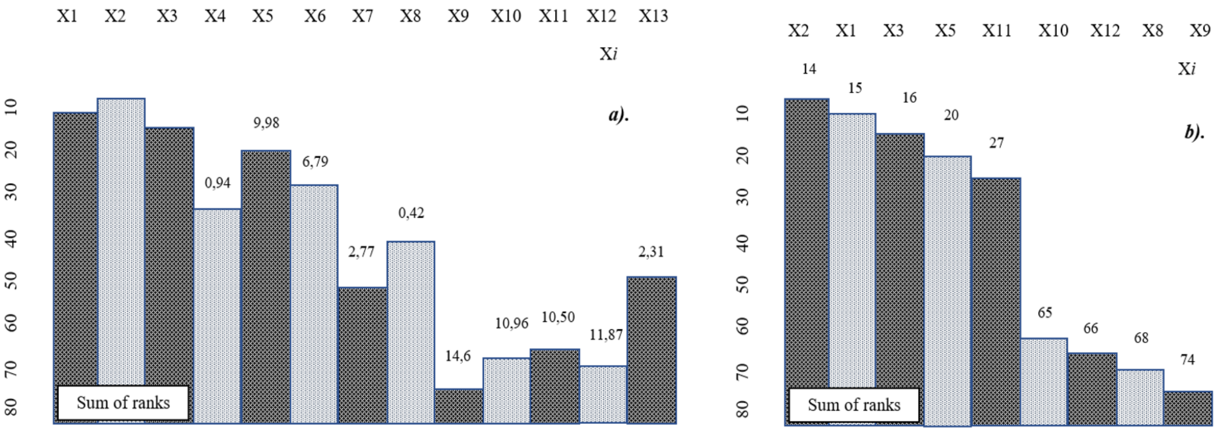

Figure 1. Ranking chart of factors affecting the quality of work A) to statistical assessment of the significance of factors; B) after ranking and determining insignificant factors.

There are the following factors:

X_1 – the angle of inclination of the sieve;
X_2 – frequency of sieve oscillations;
X_3 – amplitude of oscillations;
X_4 – level of mass supply for separation;
X_5 – the angle of application of driving force;
X_6 – the length of the sieve;
X_7 – sieve material;
X_8 – moisture of crushed mass;
X_9 – presence of cascades on the sieve surface;
X_{10} – coefficient of the live section of the sieve;
X_{11} – sizes of particles entering the separation;
X_{12} – shape of sieve holes;

X_{13} – the nature of the supply of crushed mass.

The amount of mass supplied to the separation (X_4) does not depend on the design of the device and is regulated by the initial requirements for development. The material of the sieve (X_7) and the moisture content of the separated mass cannot be changed in the process of experimental research and operation of the technological equipment. The first indicator is embedded in the design of the separator, and the second depends on the conditions before crushing. The method of supplying the crushed mass to the sieve cannot have a significant effect on the injury of the seeds, because the seeds have a high resistance to the perception of static and shock loads. After the analysis of the importance and waste of insignificant factors, the diagram of ranks was built until their value decreases in proportion to the degree of influence of one or another factor on the quality of the technological process. Rank level values are placed against the background of the chart columns. The analysis of the results of the expert assessment and their statistical processing allows us to conclude that the factors X_1, X_2, X_3, X_5, X_6 have the greatest influence on the progress and quality of the technological process. Factors $X_9 - X_{12}$ can be rejected and excluded during further research using the theory of experimental planning.

The levels of setting of independent variables (factors) and the range of their variation adopted during the experiments are given in the table 1.

Table 1. Levels and range of variation factors.

Factors	Levels of variation			Interval of variation	Dimension
	-1	0	+1		
X_1	-15	0	15	15	degree
X_2	100	300	500	200	1/s
X_3	10	30	50	20	mm
X_5	10	20	30	10	degree
X_6	1.0	1.5	2.0	0.5	m

In accordance with the experimental plan, an assessment of the dependence of technological process indicators on the frequency of vibrations of the sieve, the angle of its inclination, the amplitude of oscillations, the angle of addition of forced oscillations and the length of the separating surface, which have the greatest influence on the quality of the separator, was carried out. Repeatability of experiments for each of the optimization criteria – three times. In each line of the plan, the average value of DS, LS and PS was calculated. Experimental studies were carried out on seeds of cucumber (variety 'Konkurent') and melon (variety 'Ukrainka'). After statistical processing of experimental data, mathematical models describing the technological process were obtained.

3. Resource-saving method of extracting cucumber and melon seeds

There are presented the resource-saving method of extracting cucumber and melon seeds. It can be realized by the modernized construction of the cucumber and melon seeds separator the feature of which is the use of a two-screen sieve system. In the given system, the upper sieve separates the peel, and the lower sieve separates the seeds and pulp; the pulp and juice will be the by-product of the second sieve. The sieve, which performs an inertial movement, helps to extract the seeds associated with the peel. The technological scheme of extracting cucumber and melon seeds with experimental separator excludes stage of rubbing seeds that can prevent its damaging. The resource-saving method of extracting cucumber and melon seeds can help to reduce the amount of water needed for further washing of the seeds.

The separator is a system consisting of two sieves. With the help of the upper sieve, the coarse fraction of the crushed peel is separated, while the lower sieve separates the seeds. Other

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fractions fall into the tray, namely pulp, pulp particles and juice. In order to reduce the loss of seeds in the peel fraction, it is advisable to use the mode of the inertial separator. Carrying out additional friction of the material against the edges of the holes in the peel fraction reduces the seed content. The mode of the vibrating conveyor for the second sieve is used to increase the passage of pulp through the sieve openings. There is presented the structural scheme of the cucumber and melon seed separator designed for cleaning seeds from pulp and crushed peel particles (figure 2). The technological process is as follows: the fruits are loaded with a special conveyor into the hopper 2 of the grinding chamber 3. Crushed by drums 4; 5 mass enters the sieve 10. The dimensions of the cells of the upper sieve for cucumber 5x15 mm. On its surface, the crushed peel (over-sieve product) is removed from the technological zone. Seeds, pulp and small pieces of peel equal in size to the seeds (product of grating) fall on the surface of the sieve of the second sieve 11 with the size of the holes. Seeds with impurities on its surface are fed for further cleaning, and pulp, juice and other small impurities fall into the tray and from it into pump 4.

The following adjustments are provided in the separating device:

- the rotation frequency of the cranks and, therefore, the frequency of the sieves oscillations was changed by V-belt variators 19; 20;
- the angle of inclination of the grating was changed by adjusting the length of hinged suspensions of sieves 12; 13;
- to change the length of the working part of the separating part of the sieve, partitions were installed along the movement of the technological product.

There are presented technological schemes of extracting cucumber and melon seeds with basic and experimental separator (figure 3). The second scheme excludes stage of rubbing seeds that can prevent its damaging and allows to significantly reduce water consumption when washing seeds and achieve an improvement in the quality of the technological process.

4. Results

In the course of the research:

- the factors that have the greatest influence on the quality of the technological process and are most amenable to regulation have been identified;
- an experimental setup with variable gratings and the ability to adjust the main parameters is presented;
- experimentally investigated the dependence of seed purity (PS), its losses (LS) and damaging (DS) on the frequency and amplitude of vibrations of the sieve, the angle of inclination of the sieve and the angle of application of the vibration force, as well as the length of the working zone of the separator.

The frequency of sieve vibrations, the amplitude of sieve vibrations and the length of the sieve have the greatest impact on the quality of the technological process. This is evidenced by the largest value of the coefficients for these factors in the regression equations. By equating to zero the value of the angle of inclination of the sieve and the angle of application of the force, the regression equations have the form:

$$PS = 65.519 + 2.802X_2^2 + 1.852X_3^2 + 6.507X_2 + 3.573X_6 - 0.645X_2X_3 + 1.572X_2X_6 + 1.209X_3X_6 \quad (1)$$

$$DS = 4.252 + 1.788X_2^2 + 1.522X_3^2 + 2.155X_6^2 + +0.387X_3 + 1.487X_6 - 0.987X_2X_6 \quad (2)$$

$$LS = 6.013 + 0.993X_2^2 - 0.907X_6^2 - 1.38X_3 - 1.948X_6 + 0.493X_2X_3 \quad (3)$$

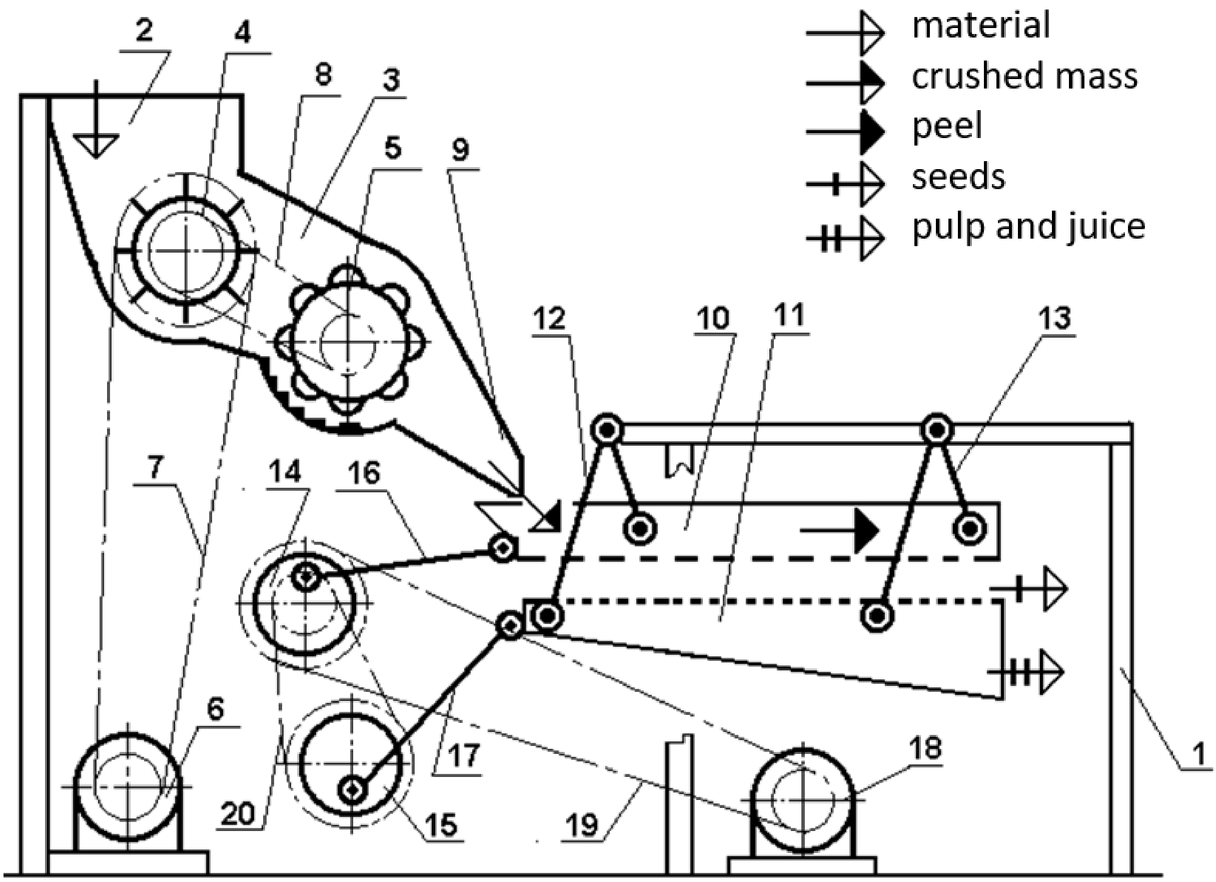

Figure 2. The scheme of the prototype of the cucumber and melon seed separator (1 – frame; 2 – receiving hopper; 3 – grinding chamber; 4 – grinding drum; 5 – wiping drum; 6 – electric motor; 7 – V-belt transmission; 8 – V-belt variator; 9 – tray; 10, 11 – the last grates; 12, 13 – sieves; 14, 15 – crank and connecting rod mechanisms; 16, 17 – hinged rods; 18 – electric motor; 19 – V-belt transmission; 20 – V-belt variator).

However, these equations are also not subject to canonical transformation, because they have an "extra" factor. It is equated $X_6 = -1$, after which the regression equations transform:

$$PS = 61.946 + 2.802X_2^2 + 1.852X_3^2 + +4.935X_2 + 1.209X_3 - 0.645X_2X_3 \quad (4)$$

$$DS = 4.929 + 1.788X_2^2 + 1.522X_3^2 + 0.987X_2 + 0.387X_3 \quad (5)$$

$$LS = 6.954 + 0.993X_2^2 - 1.384X_3 + 0.493X_2X_3 \quad (6)$$

Two-dimensional intersections of the response surfaces are presented.Having successively fixed both at the +1 level, and having performed calculations similar to the above, it is obtained the regression equation in the usual form with a new mutual combination of factors. When $X_2 = +1$, the regression equation takes the form (figure 4).

When setting the length of the sieve at the minimum level, it is impossible to achieve seed purity of more than 72%. The zone of optimal combination of factors is limited by the arcs of the HP curves; LS and DS intersecting at points I; II: III. At the same time, seed purity is within 71-72%; damaging will be less than 6%, and losses will not exceed 7%. For the vibration frequency of this technological mode is 24.3-36.25 (1/s), and the amplitude is 34-46 (mm). If the seed purity indicator drops to 71%, and losses to 8%, the range of permissible variation of

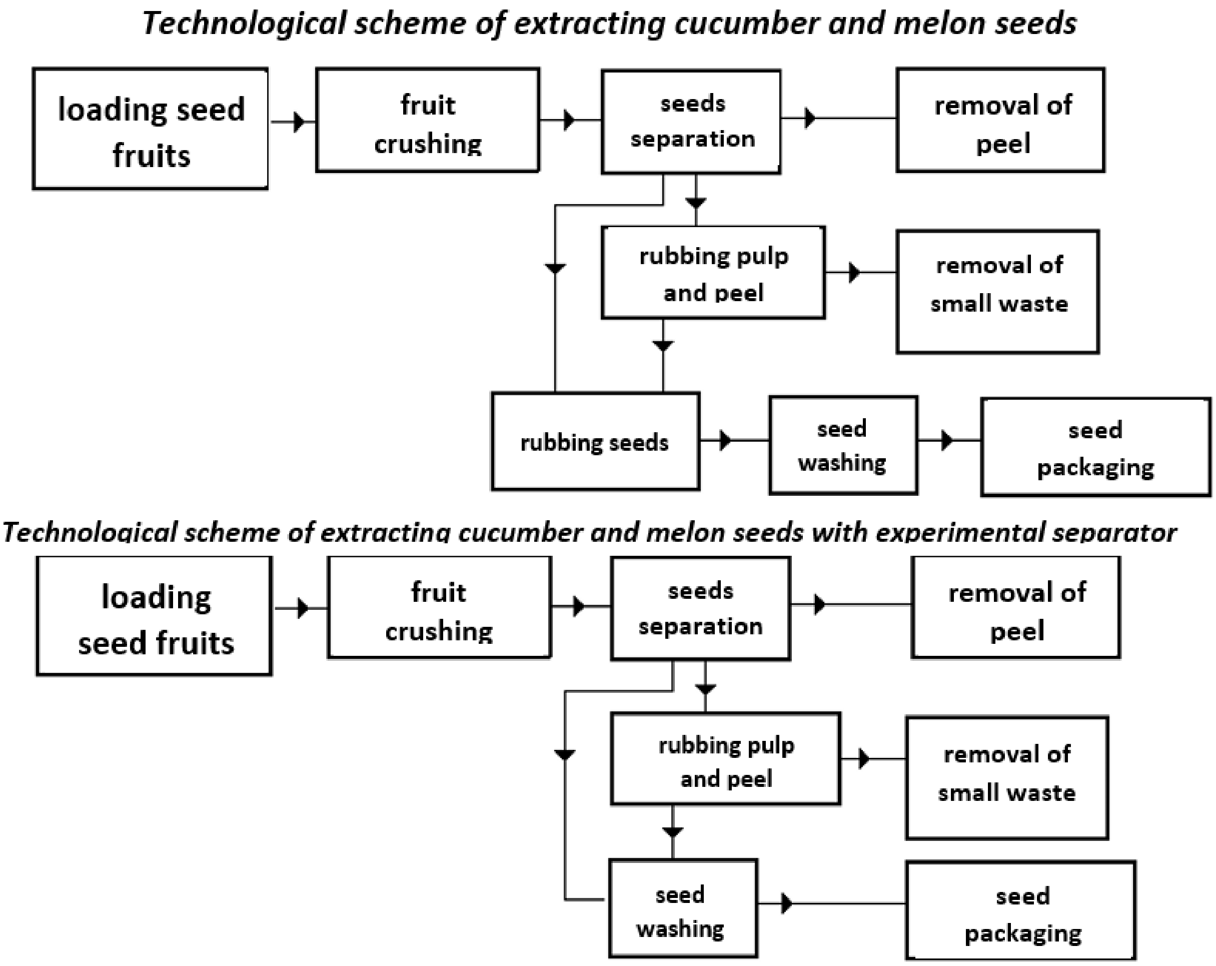

Figure 3. Technological schemes of extracting cucumber and melon seeds with basic and experimental separator.

kinematic modes (the figure is limited by points IV, V, VI) will be: for frequency – 24.3-45.0 (1/s); for an amplitude of 25-42 (mm).

Two-dimensional intersections of the response surfaces are shown in figure 5. Having successively fixed both at the +1 level, and having performed calculations similar to the above, it is obtained the regression equation in the usual form with a new mutual combination of factors.

When $X_2 = +1$, the regression equation takes the following form.

The analysis of the results of the experiment, the graphic interpretation indicates an increase in the indicators of the technological process when the frequency of oscillations is fixed at the maximum level. It was possible to achieve damage of seeds less than 4% with their purity more than 75% and losses in the range of 6-7% (the figure is limited to points I, II and III). The amplitude of oscillations is in the range of 24-32 mm, and the length of the working part is 1.51-1.625 m. In case of deterioration of damaging indicators to 5%, it is possible to achieve seed purity of more than 77.5% and losses do not exceed 6% (the figure is limited by points IV, V and VI). Independent factors can lie in the range: amplitude – 25-40 mm; sieve length – 1.75-1.825 m for a frequency of oscillations of 24.0-42.0 (1/s), for an amplitude of 24-48 mm.

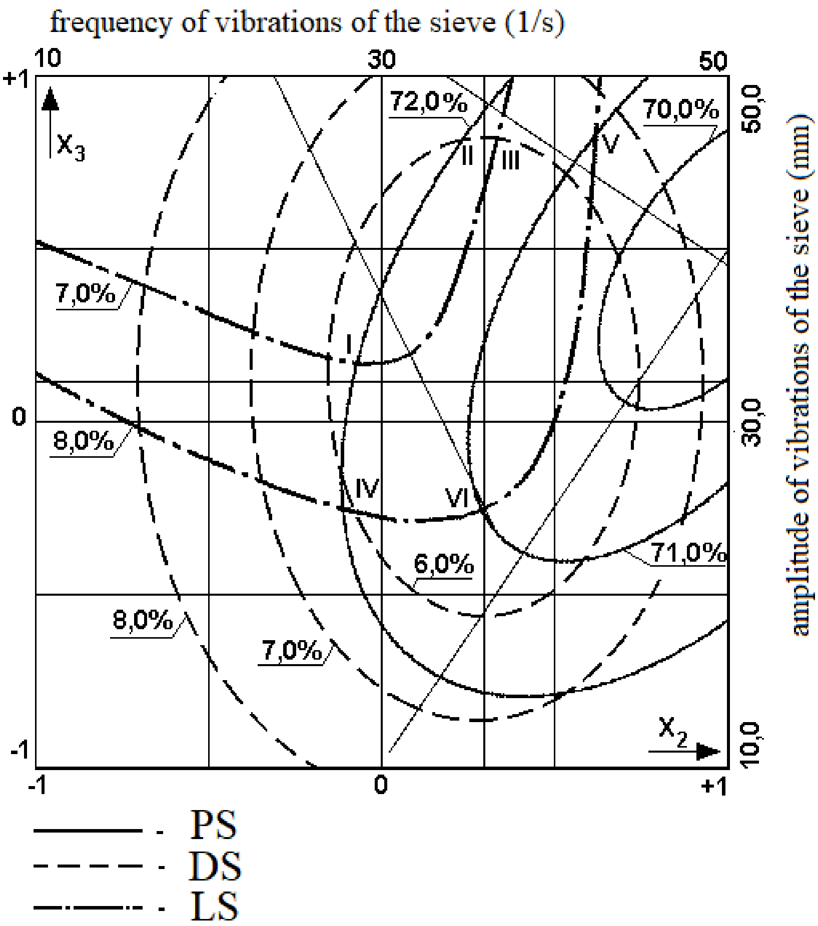

Figure 4. Two-dimensional intersections of response surfaces at $X_1 = 0; X_6 = -1; X_5 = 0$.

$$PS = 74.825 + 1.852X_3^2 - 0.645X_3 + +5.145X_6 + 1.209X_3X_6 \quad (7)$$
$$DS = 6.040 + 1.522 + X_3^2 + 2.155X_6^2 + 0.387 + +X_3 + 0.491X_6 \quad (8)$$
$$LS = 7.006 - 0.907X_6^2 - 0.891X_3 - 1.948X_6 \quad (9)$$

When $X_3 = +1$:

$$PS = 67.371 + 2.802X_2^2 + 5.865X_2 + +4.776X_6 + 1.572X_2X_6 \quad (10)$$
$$DS = 6.144 + 1.788X_2^2 + 2.155X_6^2 + 1.478X_6 - -0.987X_2X_6 \quad (11)$$
$$LS = 4.625 + 0.993X_2^2 - 0.907X_6^2 + 0.493X_2 - 1.948X_6 \quad (12)$$

Two-dimensional intersections of the response surfaces for the considered cases are shown in figure 6.

Analyzing the last graphic dependence, it can be concluded that in order to achieve the values of quality indicators of the technological process, which are comparable to the two previously considered options, it is necessary that the frequency of vibrations is 9.0-42.0 (1/s), and the length of the working part of the sieve is 1.2-1.6 m. The given combination of factors corresponds to the figure bounded by points II; III; IV, limited by the curves $PS = 70\%$, $DS = 6\%$ and $LS = 8\%$.

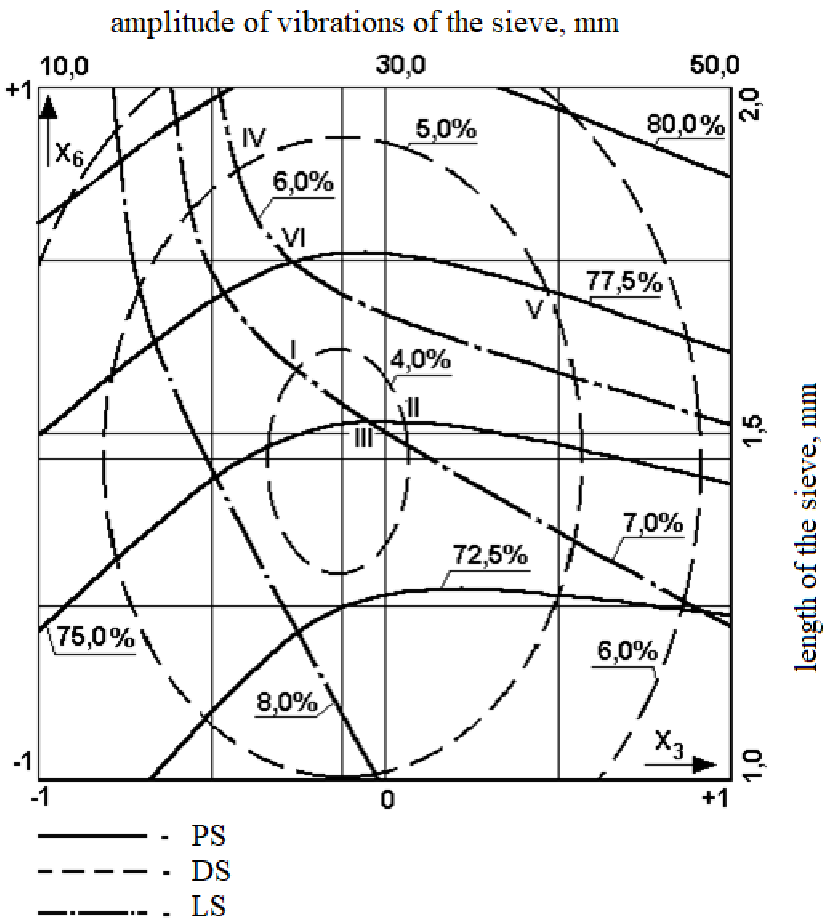

Figure 5. Two-dimensional intersections of response surfaces at $X_1 = 0; X_2 = +1; X_5 = 0$.

There are analyzed the graphical interpretation of the results of the experiment. Considering the constructed lines of "equal output", can be concluded that the task of optimizing the main kinematic modes and design parameters is contradictory. An increase in any of the investigated factors: frequency of oscillations, amplitude of oscillations and length of the sieve leads to an improvement in the indicators of seed purity (PS) and their losses (LS), but to a certain extent worsens the indicators of damaging (DS).

5. Discussion

With the increase in the average annual air temperature on the planet and the aridity of the climate, their areas have a tendency to progressively expand. In the southern regions of Ukraine, zones of harmful agriculture are created due to the increased concentration of salts in the soil, which also suppresses natural flora and limits cultural diversity. The main reproductive organ of plants, the seed, is a unique product of evolution with a variety of morphological, physiological and biological characteristics, including different adaptability. Therefore, obtaining high-quality seeds and reducing resource costs for the technological process is an important task [26].

A lot of procedures in the technological processes are currently completed by people. Because of this, a big number of melon farms need a big amount of funding and human resources. Additionally, workers can measure the fertiliser solution incorrectly or fail to prepare the water and fertiliser solution needed for each planting step. The entire melon plant may be impacted by this and suffer harm as a result. Furthermore, low- to middle-class farmers who cannot

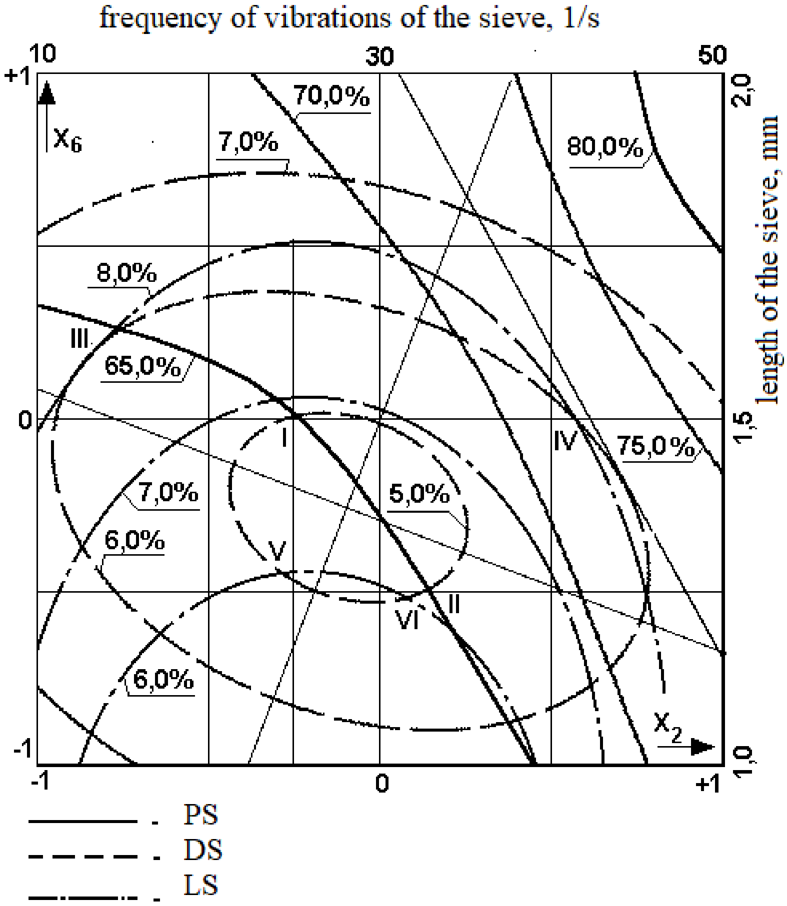

Figure 6. Two-dimensional intersections of response surfaces at $X_1 = 0; X_3 = +1; X_5 = 0$.

afford to make large investments in sophisticated machinery operate the majority of small and medium-sized melon fields [27].

A scientific notion of microwave energy's influence on grain crop growth rate under significant chemical reactant reduction was developed through systematic joint experiments conducted in both laboratory and field settings. A technique for treating vegetable crops' seeds that guarantees development rate has been devised; this is crucial for greenhouse vegetable farming. The findings that the microwave treatment increased the germination rate of melon seeds from 10% to 83% are interesting from a practical standpoint [28].

Energy-efficient agricultural equipment of low-productivity enterprises, according to its design, allows to use a simple technological scheme and reduce energy and resource costs for the technological process in the context of use in sustainable food systems [29].

From the analysis of previously conducted studies, it was established that determining the optimal relationship between the structural and kinematic parameters of separating devices of any type is a rather difficult task. In order to reduce the volume of experimental research, reduce the number of adjustments of the laboratory installation, the number of its working organs, as well as to obtain objective information about the dependence of seed injury, their purity and the amount of losses from the simultaneous change of several kinematic modes. Industrial machine models built for intricate production process automation and mechanisation are necessary for the growth of vegetable and melon seed production. Enhancing and growing the seed production sector will contribute to ensuring that agricultural production has access to seeds produced on-

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site, which will cut costs and boost industrial productivity. If growers of vegetables and melons generate their own seeds, they can lower the cost of producing these crops.

Vegetable and melon seeds are commonly separated using vibrating machinery. Chen and Yan [30] present their investigation on simulating crop sieving at varying vibration amplitudes, frequencies, and angles. The findings indicate that the sieving efficiency is not significantly affected by the vibration direction's angle of departure. The sieving efficiency rises and subsequently falls as other factors are taken into account. With an amplitude of 4 mm, a vibration frequency of 13 Hz, a sieve angle of 8°, and a vibration direction angle (angle between the vibration line and the Z-axis) of 0°, the optimal combination of sieving parameters was discovered after analysing the data. As in the case of the suggested design solution, the combination of vibration and inertial motion has a favourable impact on the quantitative and qualitative markers of seed separation [30].

The practical use of imbalanced vibration drives in adjustable drives of vibrating sieves has been investigated [31]. Both the operation of vibrating screens in the so-called "superresonant" mode and frequency control of the exciting force of the vibration motors are necessary for synchronous operation. The most significant experimental findings that were acquired under actual working settings are presented in this paper together with an experiment to ascertain the amplitude-frequency characteristics of vibrating screens. The authors' design strategy, which maximises design and operating parameters through the use of graphs, allows for a decrease in losses and an increase in seed yield [31].

For the goal of sorting seeds, Kaliniewicz et al. [32] assessed the correlations between the primary physical characteristics of seeds from a chosen species. Five species' seeds were examined for physical characteristics, and correlation and regression analysis were used to establish whether these features were interrelated. Sorting seeds using a sieve with two or more screens is recommended. The study highlights the necessity of technology tools for farms to process agricultural produce after harvest, with vibration machines being especially useful in this regard. By using the suggested design approach, high-quality seed separation is ensured by additional work in the inertial mode in addition to the use of vibrating machine properties [32].

The best values for the design and operational parameters of seed separators can be found by simulating the technology of processing the seed mass of vegetable and melon crops [33]. The researchers offered a solution to the seed characteristic prediction challenge. The final material's purity and seed loss were the optimisation criteria. On the other hand, compared to vibrating equipment, the pressurising machine employed in the experiment produced less-quality seed separation. Furthermore, the proposed study of the movement of the technological mass of vegetable and melon seeds allows for the optimal operating modes of the separator to be chosen using the suggested graphs, whereas the mathematical modelling of the technological process is time-consuming, only allows for modelling a specific sample of varieties of vegetable and melon crops, and does not allow for the prediction of the results [33]. As demonstrated by the experimental data gathered based on the mechanical and technological characteristics of the chosen samples, the combination of inertial and vibration motion of the sieves is the benefit of utilising the suggested design solution for the separator. It is possible to reduce the amount of water needed for seed washing and improve the level of the technological operation by using a resource-saving method of extracting cucumber and melon seeds.

6. Conclusion

The lack of modern, highly productive equipment does not allow to fully realize the possibilities in providing agriculture with its own seeds of cucumber and melon. The purchase of seeds leads to additional expenses, reduces the productivity of open ground melon cultivation due to the fact that not all varieties are regionalized. There are studies on the substantiation of the design parameters and kinematic modes of seed separators from the crushed peel and pulp obtained in the process of crushing seed fruits. The conducted theoretical justification applies only to sieve-type separators with a horizontal sieve with reciprocating movement and constant pressure of particles of crushed mass on the surface of the sieve.

Using the proposed method of extracting cucumber and melon seeds allows to lower the amount of water used for seed washing and raise the standard of the technological procedure. The feature of the proposed design solution of the separator of the melon and cucumber seeds is that the upper screen operating in the mode of an inertial separator and the lower screen operating in the mode of a vibrating separator that promotes better separation of seeds. The upper screen separates the coarse fraction of the crushed peel, while the lower screen separates the seeds. The remaining fractions, such as pulp, pulp particles and juice, fall into the tray. To reduce seed losses in the peel fraction, it is advisable to use the inertial separator mode. Additional friction of the material against the edges of the holes in the peel fraction reduces the seed content. The mode of the vibrating conveyor for the second sieve is used to increase the passage of the pulp through the sieve holes.

Factors affecting the quality of the technological process of the proposed solution of the cucumber and melon separator were identified: the angle of inclination of the sieve surface, the frequency of oscillations of the sieve, the amplitude of its oscillations, the angle of application of the vibration force and the length of the sieve. The following optimization criteria were chosen: purity of seeds, the extent of their damage and the level of seed losses. The factors that have the greatest influence on the quality of the technological process have been established: the frequency of vibrations of the screen, the amplitude of vibrations and the length of the working surface of the sieve. At the same time, the ranges of variation of independent factors made it possible to ensure modes of both inertial separation and vibration separation. The ranges of the optimal combination of independent factors are as follows: in case of seed injury 4-6%, purity 70-75%, losses are within 6-7%, a necessary condition is the frequency of oscillations 9.0-42.0 (1/s), the amplitude oscillations of 24-32 mm, and the length of the working part sieve 1.2-1.6 m. In the vibroseparation mode (oscillation frequency more than 30 (1/s); amplitude more than 35 mm (with an angle of application of the vibration force of 10°) seed damage does not exceed 5%, and their frequency is within 70...71%. At the same time in the inertial mode separator, seed loss at the level of 5-6% is achieved. Prospects for further research are recommendations on the design schemes of separator, its kinematic modes, which allows to intensify the process of cleaning freshly separated wet seeds from organic impurities.

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