

Research Article

# Development of a Device for Primary Purification of Mung Bean Grain from Pods and Optimization of Its Main Design Dimensions and Operating Modes

Achilov Elyor Temirovich\* 

Machinery Faculty, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan

## Abstract

It is important to create a technically and technologically improved device that reduces the damage to the mung during the process of removing the pods from the currently cultivated mung grain. Therefore, it is necessary to develop the design of the device, to justify its parameters and operating modes, for the complete separation and preliminary cleaning of mung beans without damaging them. The article presents the results of optimization of the main design dimensions and operating modes of the device for separating mung bean from the pods. The results of experimental studies showed that the proposed device has a high degree of completeness in separating mung bean from its pods and a low level of damage, low grain damage and high grain purity, which can be ensured with a sag length of 170 mm, a shaft oscillation number of 300 min<sup>-1</sup>, the amplitude of the shaft is 11.5 mm, its angle of inclination is 12 degrees. The design of the device for preliminary cleaning of mung grain by separating it from pods has been developed. The scientific significance of the research results is based on the structural dimensions and operating modes, as well as the resulting analytical connections and mathematical models, to ensure the quality of initial cleaning, to separate mung beans from pods completely and without damage, using less energy and resources. can be used to justify the parameters of similar devices. The developed device reduces the consumption of energy and labor during the initial cleaning of mung grain from pods, as well as the loss of grain.

## Keywords

Mung, Bean, Grain, Crusher, Device, Angle, Amplitude, Hopper

## 1. Introduction

It is known that one of the most important tasks is to carry out research work aimed at developing technologies and technical means that ensure high-quality implementation of the processes of primary cleaning of agricultural seeds from ears and pods, increasing their efficiency. According to Rosaboyev and Pardayev [1], one of the most important tasks of agricultural engineering is to increase the energy efficiency and re-

source intensity of structurally simple devices for the primary purification of agricultural crops from grain legumes to the level of agrotechnical requirements for the proper establishment of crop production on farms and reduction of costs.

There are also several types of machines that clean or separate small-sized seeds from extraneous impurities. According to their structure, they are divided into types that clean the

\*Corresponding author: mirzoxidta@gmail.com (Achilov Elyor Temirovich)

**Received:** 24 July 2024; **Accepted:** 13 August 2024; **Published:** 27 August 2024



Copyright: © The Author(s), 2024. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

seeds in the air stream, with and without air, with and without hopper, with wheels and without wheels.

Recently, according to the findings of Mukhammedov *et al.* [2], Lee [3], Tukhtabayev *et al.* [4] and Rosaboev *et al.* [5] believe that the method of collecting agricultural crops and processing them in a stationary station is one of the promising methods, and they believe that the method of harvesting in a combine harvester and grain cleaning should be used together and complement each other.

Tukhtamirzaevich [6] and Pardayev *et al.* [7] highlight the analysis of the methods of harvesting leguminous grain crops and processing them in threshing machines and the technical means that implement them shows that these technologies and technical means are mainly intended for farms with large areas and regions with colder climatic conditions. For this reason, they are ineffective in the small-scale farmers and peasant farms of Uzbekistan.

Astanakulov *et al.* [8, 9], Rasulov *et al.* [10], Shomirzaev *et al.* [11] and Kurbanov *et al.* [12] assert that mush and other similar leguminous crops are harvested and piled in three different ways worldwide. The first method is to mow the mung bean 5-10 cm above the surface of the ground. In this method, standing mush and other leguminous crops are harvested with the following and other similar harvesters.

Based on the above, it is an urgent issue to carry out targeted scientific research work on the development of a device that is simple in structure, meets the requirements of the time, and saves energy and resources.

## 2. Materials and Methods

Knowing the moisture content of pods and stems is important in researching the technological process of extracting mung

beans from pods and stalks. Because knowing the moisture content of the mush pods and stalks at the time of hitting them with the forks, it creates a basis for the correct assessment of the technological process and the complete separation of the mung grains from the pods without damaging them.

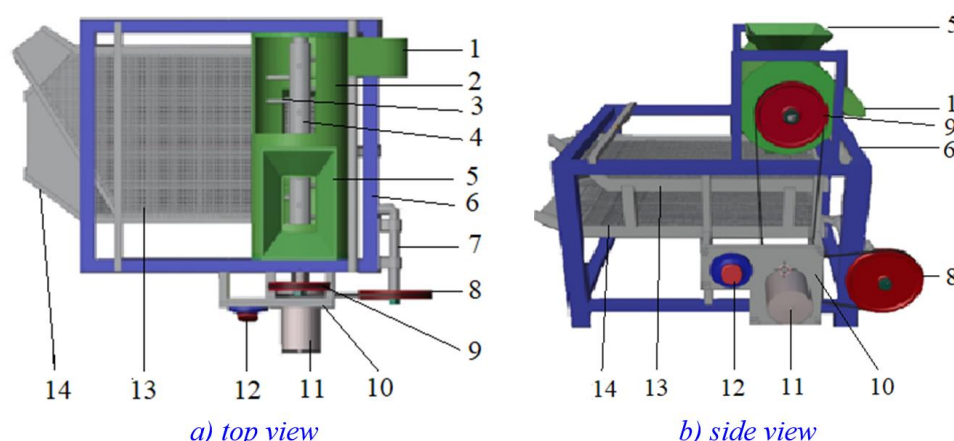
Unal *et al.* [13] and Singh *et al.* [14] delves into the geometric and mechanical properties of mung bean are important to design the equipment for processing, transportation, sorting, separation and storing. Designing such equipment without taking these into consideration may yield poor results.

In the experiments, the moisture content of 500-600 mm long mung stalks was measured every 100 mm using an EV-2K electronic moisture meter. The humidity of the mung stem decreases as it rises from the throat.

How to use the EV-2K electric moisture meter. Scales are checked for display before changing them. By means of manual change, an arrow is placed on the sign "Humidity Scale" ("HS"). The key must be pressed when placing the arrow on the "HS" symbol. In the direction of the stem fibers, the sharpened part of the needle is completely immersed in it. To make the result more accurate, the measurement is repeated several times and the average value is calculated.

The creation of improved energy-resource-saving devices to perform the above work on farms is one of the pressing problems of today. To eliminate this issue, in the course of earlier research work, a scheme for a device for the primary purification of small-scale mung grain from pods of a new design was developed (Figure 1).

Based on the design diagram of the device shown in Figure 1, its operating modes and parameters were determined as a result of theoretical studies, and an experimental copy of the device for the primary cleaning of small-scale mung grain from pods of a new design was developed (Figure 2).

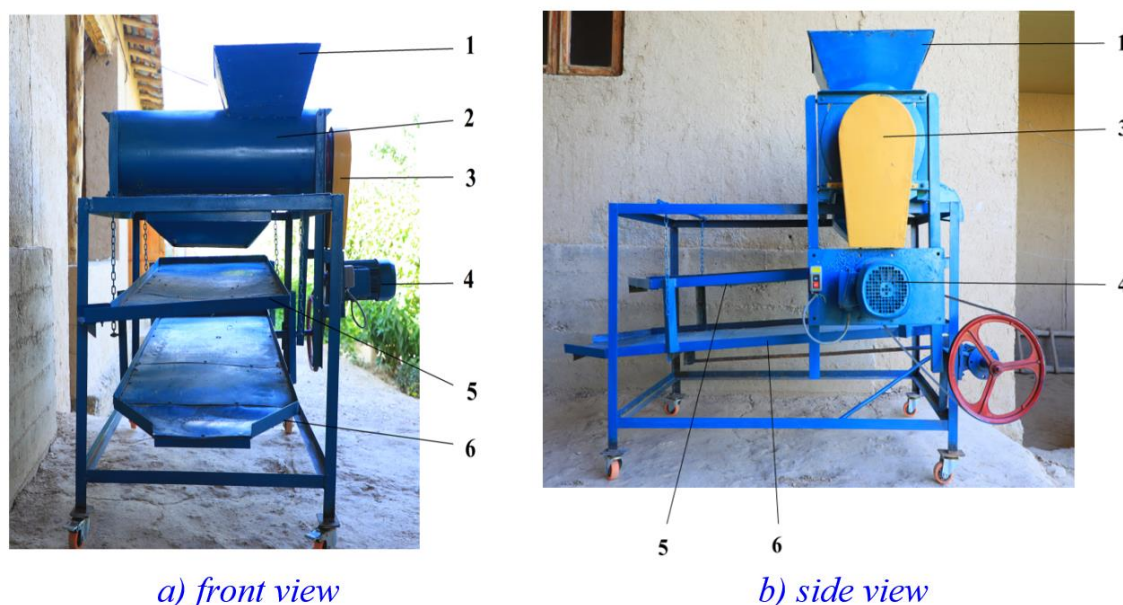


**Figure 1.** Design and technological diagram of a device that separates the mung grain from the pods and cleans it. 1-outlet; 2-cylinder 3-valve; 4-shaft; 5-load hopper; 6-frame; 7-rod that moves the wheels; 8 and 9 – pulleys; 10-base; 11-electric motor; 12-on or off switch; 13-top protection; 14- lower jaw.

Figure 1 shows the structure and technological scheme of this device. The principle of its operation is as follows: when

connecting to the network, the start button 12 is pressed, and the shaft 4, on which the rods 3 are fixed in the form of a screw, rotates with the help of the electric motor 11 and pulleys 8 and 9. At this time, mush stalks with legumes are loaded. When pods of pods fall into the cylinder 2 from the loading hopper 5, the rotating blades 3 hit them and separate the pods from the pods as a result of the force of impact. Since the rods 3 are screwed to the shaft 4, they also push the rods forward in the direction of rotation. Grains that have not been separated from their pods are completely separated as a result of being hit by other sieves 3 in the direction of movement and pushed forward. Grains separated from pods,

large and small pods, and pieces of stems pass through the gill-like base and fall to the upper gill 13. Large particles in the seed mixture are trapped in this sieve. The seed and small inclusions pass through the sieve eyes and fall into the lower sieve 14, and the small foreign substances are separated. Clean grains move along the surface of the lower conveyor 14 and fall into the container. The foreign substances separated by the upper and lower filters fall into a separate container. The shafts move back and forth with the help of the connecting rod 7. Pieces of crushed stems, ears and pods are thrown out through a special discharge hole 1 installed in the cylinder, and the technological process continues in this way.



**Figure 2.** Overview of an experimental copy of the device for the primary purification of mung grain by separating it from the pods. 1–transfer hopper; 2–cylinder; 3 – means of protection; 4–electric motor; 5–top drum; 6–Bottom drum.

### 3. Results and Discussion

Multifactorial experimental studies were carried out to identify connections between factors influencing the technological process of primary purification of this mung grain from pods, as well as their optimal values. Based on previously conducted research works, scientific literature, the results of theoretical and practical studies, as well as preliminary experimental studies, it was established that the number of shaft revolutions, the number and length of mung pods, and the technological process have the greatest influence on the technological process of extracting mung grains from pods. During primary cleaning, the greatest influence is exerted by the number of roller oscillations, the amplitude of the roller oscillations and the angle of inclination of the roller. For this

reason, to determine the optimal values of the main structural dimensions and operating modes of the primary purification plant by separating mung grain from the pods, large-scale experiments were carried out using plan B3. The completeness of grain extraction from the pods for the process of extracting grain from mung pods and the degree of their damage, the purity and integrity of the grain for the process of primary cleaning of mung grains were taken as criteria for evaluating multifactor experiments.

Based on the results of preliminary experiments and theoretical and practical studies, the limits and intervals of changes in factors were determined.

Table 1 shows the main factors, limits and intervals of their change.

**Table 1.** Main factors, limits and intervals of their change.

For the technological process of separating mung grains from pods						
Name of factors	Designation		Limit of change			Range of change
	Real	Coded	-1	0	+1	
Number of shaft revolutions, rpm	$N$	X1	300	350	400	50
Number of grains, pieces	$Z_k$	X2	15	18	21	3
Length of studs, mm	$l$	X3	160	165	170	5
For the technological process of mung grain cleaning						
Number of drum vibrations, min-1	$n_t$	Y1	300	350	400	50
Amplitude of drum vibrations, mm	$A_t$	Y2	9	12	15	3
Angle of inclination of the kingpin, degrees	$A_l$	Y3	6	9	12	3

\*Table Footer.

Pardayev *et al.* focus on [15] the relationship between factors influencing technological processes and the results obtained is expressed in the form of the following regression equation.

$$y = b_0 + \sum_i^k b_i x_i + \sum_{i>y}^k b_{ij} x_{ij} + \sum_{i=1}^k b_{ic} x_i^2, \quad (1)$$

in this case, y is the optimized criterion of the process under study;

$b_0, b_{ij}, b_{ii}$  - invariant regression coefficients;

$x_i, x_{ij}$  - changing factors.

Factors that facilitate calculations were coded as follows:

$$X_i = \frac{X_i - X_{oi}}{\varepsilon} \quad (2)$$

in this case, the conditional value of  $X_i$  – factors;

Actual value of  $X_i$  factors;

$X_{oi}$  - actual value of zero level factors;

$\varepsilon$  - actual value of the factor change interval.

In the process of determining the significance of regression coefficients, the Student's test was used at the 0.05 level.

The adequacy of the process model was checked using Fisher's test.

If

$$F_{\max} < F_{\text{табл}}(0,05), \quad (3)$$

Then the technological process model is considered adequate.

Three observations were made for each experiment. A table of random numbers was used to determine the sequence of experimental studies. Regression equations were obtained for the completeness of extraction of mung grain from the pods

and the degree of their damage, as well as the purity and loss of grain during the primary cleaning of mung grain. From these equations, the optimal values of the main factors influencing the technological process were determined.

The results obtained in multifactorial experimental studies on the primary purification of mung grain by separation from the pods were calculated and processed using special software available on a computer. Using this program, the following regression equations were obtained that adequately express the completeness of separation of grain from the pods and the degree of their damage during the technological process of extracting grain from the pods, as well as the purity and loss of grain during the technological process of primary cleaning of mung grain:

- extraction of grain from pods by completeness

$$Y_1 = 94,645 + 2,615 X_1 + 4,511 X_2 - 9,762 X_3 - 1,060 X_1^2 - 8,864 X_1 X_2 + 1,580 X_1 X_3 - 9,320 X_2^2 + 3,300 X_3^2, \% \quad (4)$$

- according to the degree of grain damage

$$Y_2 = 1,43 + 0,156 X_1 - 0,467 X_2 - 0,891 X_3 + 0,123 X_1^2 + 0,368 X_1 X_3 + 0,614 X_2^2 + 0,468 X_2 X_3 - 1,285 X_3^2, \% \quad (5)$$

- by grain purity, (%)

$$U_q = 98,168 + 0,325 X_1 + 0,368 X_2 + 0,321 X_3 + 0,276 X_1 X_2 - 0,204 X_2^2 + 0,357 X_2 X_3; \quad (6)$$

- by grain loss, (%)

$$U_l = 0,023 + 0,005 X_1 + 0,005 X_2 + 0,006 X_3 + 0,003 X_1^2 + 0,003 X_1 X_2 + 0,013 X_1 X_3 + 0,014 X_2^2 + 0,008 X_2 X_3 - 0,003 X_3^2 \quad (7)$$

Extracting regression equations (5) and (6) from mung grains with completeness  $Y_{1\max} \leq 98$  percent and the condition that they tend to the degree of damage  $Y_2 < 2$ , as well as solving regression equations (7) and (8) with grain damage 0.05 percent [min] to the value, grain purity 98.0

percent [min] before technological processes, the optimal values of the main influencing factors were determined.

Tables 2 and 3 show the results of determining the optimal values of the main factors.

**Table 2.** Optimum values of the main factors in determining the completeness of mung beans separation from their pods and the degree of their damage.

The name of indicators	Factors and their meanings		
	n, r/min	Z <sub>k</sub> , pcs	l, mm
Conditional	+0,121	0	+1
Real	353,6	18	170
Rounded	350	18	170

**Table 3.** Low grain integrity and optimal values of the main factors in determining grain purity.

The name of indicators	Factors and their meanings		
	N <sub>t</sub> , min <sup>-1</sup>	A <sub>t</sub> , mm	α <sub>t</sub> , deg.
Conditional	0	-0,56	1
Real	304,46	11,65	12
Rounded	300	11,5	12

From the results presented in tables 2 and 3, it is clear that the proposed device ensures high completeness of extraction of mung grain from the pods and a low degree of damage, low destructibility of the grain and high purity of the grain, shaft speed 350 min<sup>-1</sup>, number of feeds 18 pieces, feed length 170 mm, drum oscillation number 300 min<sup>-1</sup>, is ensured when the vibration amplitude of the drum is 11.5 mm, and its inclination angle is 12 degrees.

the number of shaft revolutions when using a blade crusher is 350 1/min, the number of crushers installed on it is 18 pieces, the length of the crushers is 170 mm, the number of oscillations of the crusher is 300 1/min, the amplitude of oscillations of the crusher is 11.5 mm, and also provided that its tilt angle is 12 degrees.

## 4. Conclusions

1. High completeness of extraction of hemp grain from the pods, low degree of damage, high grain purity and low destructibility can be achieved through the correct choice of the number of revolutions of the shaft on which the caulking is attached, the length of the caulking, the number of caulking, the number of oscillations of the caulking, the amplitude of oscillations caulk and its angle of inclination.
2. The proposed device has a high completeness of extraction of mung grain from the pods, a low degree of damage, high grain purity and low destructibility,

## Author Contributions

Achilov Elyor Temirovich is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] Rosaboyev, A. T., & Pardayev, O. R. Energy and resource saver devices for development seed producing of the leguminous crops. *Efficiency of application of innovative technologies and equipment in agriculture and water management*. 2020, 74-77.



- [2] Mukhammedov, S., Khaydarov, A., & Pardaev, O. Quality control of baby food products on the basis of results obtained using the instrumental neutron-activation analysis technique. *Uzbekiston Fizika Zhurnali*. 2013, 15.
- [3] Lee, A. Technological bases of harvesting and equipment for lucerne seeds cleanings. *Agricultural Machinery and Technologies*. 2017, (6), 28-35.
- [4] Tukhtabayev, M. A., Pardaev, O. R. Moisture and hardness of the soybean stem. *Mechanics and technology*. 2021, 4(5), 67-73.
- [5] Rosaboev, A., & Mamadaliyev, A. Theoretical substantiation of parameters of the cup-shaped coating drums. *International Journal of Advanced Research in Science, Engineering and Technology*. 2019, 6(11), 11779-11783.
- [6] Tukhtamirzaevich, M. A. Results of laboratory-field testing of hairy seeds coated with mineral fertilizers. In *Proceedings of International Educators Conference*, 2022; 1(3), pp. 528-536.
- [7] Pardayev O. R., Achilov E. T. Optimizing the main structural dimensions and operating modes of the device that separates the seeds of agricultural crops from the ears and pods. *Economics and society*. 2023, 3(106), 172-175.
- [8] Astanakulov, K. D., Babaev, K. M., Eshankulov, K. M., & Turdibekov, I. M. Development of technology and equipment for harvesting mung bean crops. In *IOP Conference Series: Earth and Environmental Science*, Tashkent, Uzbekistan, 2022, 1112(1), pp. 012008, <https://doi.org/10.1088/1755-1315/1112/1/012008>
- [9] Astanakulov K D, Rasulov A D, Baimakhanov K A, Eshankulov Kh M and Kurbanov A J. Important physical and mechanical properties of the mung bean seed for harvesting and cleaning process. In *IOP Conference Series: Earth and Environmental Science*, Tashkent, Uzbekistan, 2021; 848, pp. 012171. <https://doi.org/10.1088/1755-1315/848/1/012171>
- [10] Rasulov, A., Abduraxmanov, A., Igamberdiev, D., & Idrisov, K. Primary Cleaning Machine for Small and Medium-Sized Mung Bean Grains for Farms and Peasant Farms. In *BIO Web of Conferences*, Tashkent, Uzbekistan, 2023; 78, pp. 06006. <https://doi.org/10.1051/bioconf/20237806006>
- [11] Shomirzaev, M. K., & Umirov, A. T. Research on cutting height in soybean harvesting with a combine harvester. In *IOP Conference Series: Earth and Environmental Science*, Tashkent, Uzbekistan, 2023; 1112(1), pp. 012010. <https://doi.org/10.1088/1755-1315/1112/1/012010>
- [12] Kurbanov, A., Shomirzaev, M., Tursunov, S., Toshbekov, O., Mukhamadiev, N., Kambarov, B. & Mannobova, S. Analysis of the state of cultivation and harvesting of mung bean and agro-biological requirements for threshing and separating its grain. In *BIO Web of Conferences*, Tashkent, Uzbekistan, 2024; 105, pp. 02010). <https://doi.org/10.1051/bioconf/202410502010>
- [13] Unal, H., Isik, E., Izli, N., & Tekin, Y. Geometric and mechanical properties of mung bean (*Vigna radiata* L.) grain: Effect of moisture. *International Journal of Food Properties*, 2023, 11(3), 585-599. <https://doi.org/10.1080/10942910701573024>
- [14] H. J. Singh, De. Dipankar, P. K. Sahoo. Physical properties of soybean cultivated in NEH region of India Agricultural Engineering International: *CIGR Journal*, Open access at <http://www.cigrjournal.org> 2014, 1-5.
- [15] Pardayev O. R., Achilov E. T. Theoretical study Process of separation of agricultural crops seeds from head and pods under the influence of winders. *Modern journal of social Sciences and humanities*, Namangan, 2022, 36-41.

## Biography



**Achilov Elyor Temirovich** is a teacher of Jizzakh Polytechnic Institute, Assistant of the Department of General Engineering Sciences. He graduated from Samarkand State University in 2012, and his Master of Engineering in mathematics from the same institution in 2016. He has participated in multiple international research collaboration projects in recent years. He currently serves on the supervisor of numerous students and has been invited as a Keynote Speaker at the institute.