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Experimental studies for the Development of special equipment for cleaning cedar nuts from the shell

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ABSTRACT

The research is aimed at studying Cedar nut seeds and the use of special pneumatic reactive and centrifugal equipment for their processing. The main purpose of the work is to develop equipment for cleaning cedar grain. The article describes the features of Cedar nut seeds, which are widely distributed in the east of the Republic of Kazakhstan, and also presents a technological scheme for extracting Cedar nut kernels. The main attention is paid to the results of the development of special equipment that allows you to separate the kernels of cedar grain from the shell without damaging them. Experiments were carried out on this equipment, the results of which were presented in the form of graphs. Studies have shown what air velocities and torques are used to eject grains of various sizes when exposed to a target. In the first experiment, it is shown at what air velocity the grains are peeled from the shell, depending on their diameter, that is, cedar grains are peeled from the shell when hitting a target with an air velocity of 5 mm-41 m/s, 6 mm – 39 m/s, 7 mm – 38 m/s, 8 mm-35 m/s, 9 mm-31 m/s. In the second experiment, it is shown at which torque of the disc, depending on the diameter of the grains, that is, cedar grains are peeled from the shell when hitting a target with a torque of 5 mm – 15 N* m, 7 mm –13 N*m, 8 mm-10 N* m, 9 mm - 8 N* m.

Keywords: cedar nut, pneumatic jet, centrifugal, equipment, complex processing.

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Introduction

Research and review articles on the Cedar nut (Pinus sibirica du Tour) have so far been devoted mainly to the biochemical characteristics of its grains, and the prospects for the use of grains for medical, food and technical purposes [[1], [2]]. At the same time, the scientific literature does not sufficiently cover the technological aspects of the production of such products. Studies have shown that the average weight of a cedar grain is 0.23-0.25 grams. Grains are 9 mm, medium — 7-9 mm, small — 7 mm and less. In particular, when cedar nuts are processed into kernels or cedar oil, a shell is formed, which accounts for an average of 51-59% of the weight of the original raw material, and 5-10% of the same residue contains grains with a disturbed structure [[3], [4]]. Currently, in the Russian Federation and European countries, a large number of medicines, medicinal oils and pine nuts from pine nuts are widely used as a food additive. And in the Russian Federation, plants for the production of pine nuts as finished products are developing.

The analysis of technical means and technical literature on the separation of pine nuts from the shell showed that they are designed for large-scale production, have high energy consumption, complex technologies, and the need to use a large amount of equipment. Since the pine nut grows only in the east of Kazakhstan, only farms are cultivated around it, so small multifunctional equipment is required. The use of such equipment makes it possible to reduce transportation costs and increase the profitability of production.

That means that it is relevant to design small equipment designed to accurately separate the cedar texture from the bark without disturbing its structure. Therefore, careful processing from cedar nuts without disturbing the structure of the grain is an urgent problem. And to solve this problem, the following tasks were set:

- Study of the technical and physical characteristics of cedar nuts growing in the eastern region of the Republic of Kazakhstan;
- analysis of the scheme of installations for separating cedar nuts from the Shell to determine the promising direction of research;
- development of a project for carefully separating the Cedar grain from the bark without destroying its structure;

This article is devoted to the consideration of the main technological aspects of complex processing without disturbing the structure of the Cedar nut grain.

Experimental part

For processing Cedar nut grain, which comes in large batches, the design of the equipment changes significantly, depending on the mechanical properties, regional and climatic characteristics of the region of its growth, as well as the technology of preparation and primary processing. The large distribution of physical characteristics makes us pay more attention to the first stage of the technological process [[5], [6], [7]]. Primary sorting and calibration will allow you to highlight the nut with underdeveloped kernels and residues. The amount of primary waste can be from 3 to 15% of the total weight of raw materials. The moisture content of the seeds that come for processing is very important, they can vary from 10 to 30%. High humidity of the nuclei leads to their destruction and loss. The low moisture content of the shell increases its hardness and relative size of the nuclei, which prevents the separation of the nuclei from the Shell and beyond [[8], [9], [10]].

Therefore, when working out the industrial process of peeling cedar nuts, a sequence of operations was found that included convective drying of nuts with warm air to ~10% humidity and short-term humidification of them for 2-8 hours [[11], [12], [13]]. Thus, at a relatively low humidity of the nuclei, it is possible to achieve a high humidity of the Shell, which ensures a decrease in its strength and an increase in its relative size. As a result, the distribution indicators of finished products are significantly improved [[14], [15], [16]].

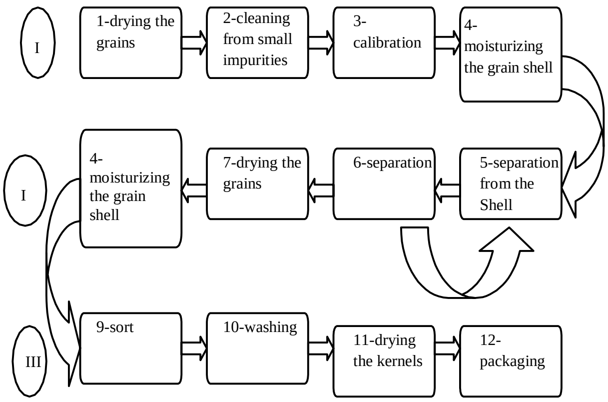

Figure 1 - Technological scheme for obtaining Cedar nut kernels

Figure 1 shows the scheme of complex processing of cedar nuts. The Cedar grain preparation stage (I) consists of four stages: (1) drying the grains, (2) cleaning them from fine impurities by airing, (3) calibration, (4) moistening the grain shells. At the stage of peeling (II), in pneumatic or centrifugal peeling equipment, the grain is separated from the shell (5), in the drum separator (6) there is a destruction of the grain shell, that is, the separation of the shell from cedar nuts and unprocessed grains, then the peeled grains are pre-dried in a convection drying cabinet (7), and then the cleaning of the protective film (8) is performed. At Stage III, grain sorting (9), washing (10), drying (11) and packaging (12) are carried out [[17], [18]].

Since the kernels of nuts on the market must meet the requirements for environmentally friendly food products, we know that during their processing it is not necessary to use any chemical reagents, high temperatures and other effects that can lead to partial destruction of the protein - vitamin complex of the seeds. For this reason, of all the possibilities, the mechanical method of separating the grain from the Shell was chosen. Traditional mechanical methods of processing grains are relatively simple and usually involve separation from the Shell between rotating cylinders or millstones [[19], [20]].

In semi-industrial conditions, reactive stripping equipment has been tested, which works as follows. Cedar nut seeds through the ejector node (figure 2) the accelerator enters the tube, where it gains a speed of ~ 40 m/s with an air flow, and then, when hitting the target, they are reflected. The impact Force acquires efficiency with a change in the speed of the air flow due to the strength and elasticity of the shell. This makes it possible to reduce the destruction of the nuclei during impact to a minimum. The disadvantages of this method should include relatively low performance and low efficiency, since the efficiency of air compression is low. In addition, it is necessary to purify the compressed air from compressor oil vapors, otherwise the chemical composition of the grain may change.

Therefore, for an industrial installation, a device without the above disadvantages is a multi – channel centrifugal stripping equipment (figure 3) applied. It works as follows. From the hopper, cedar nuts are fed by the dispenser to a disk of radius R, which rotates at an adjustable angular velocity, where, under the influence of centrifugal force, N is distributed along radial channels. By friction against the walls of the channels, the grains acquire a linear velocity close to r at the exit, and then reflect when hitting the target.

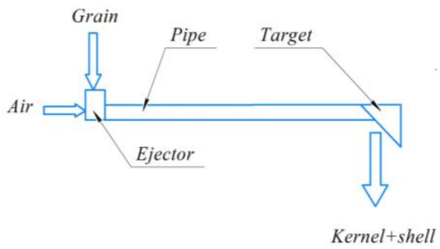

Figure 2 - Pneumatic jet stripping equipment

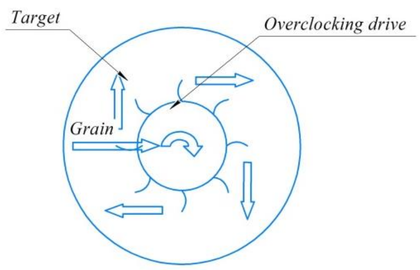

Figure 3 - Multi-channel centrifugal stripping equipment

The resulting grain is sucked into a tube through the ejector assembly, where it is accelerated by airflow. At the moment of hitting the target, its reflection occurs. The nuclei and shells are discharged into the receiver by air. The resulting grain is fed to the centre of the rotating accelerator disk, where it is distributed through radial channels and, having a linear speed close to r in them, hits and reflects the annular target.

This force is determined by the time the grain pulse collides with the normal target. In turn, the collision time depends on the elasticity of the grain shell, that is, its moisture and direction at the time of collision.

To assess the effect of air velocity on the separation of the shell from the grain, a number of experiments were conducted, where sensors were installed at various points to measure air velocity in different parts of the target and due to centrifugal force. In the first type of experiment, cedar grains with different diameters were used as a control group to determine how the diameter affects the air velocity required to peel them from the shell. In the second case, by setting different speeds of rotation of the disk, the centralizing force was calculated and the efficiency of separating the shell from the grain at each speed was measured.

An analysis of the data was carried out in order to determine the relationship between the grain diameter, the air velocity and the disk required for their purification. Due to this, a dependence graph was constructed and statistical methods were used to assess the significance of the results obtained.

The study was carried out on special equipment that allows you to separate the kernels of cedar grain from the shell without damaging them. The data was processed using Statistica 10 statistical analysis software. A one-factor analysis of variance was performed for different grain diameters.

The results of the experiment showed that grain diameters require higher air velocities for successful shell cleaning and this is useful for optimizing the cleaning process. This process made it possible to quantify the effect of grain diameter on the air velocity required to peel them from the shell.

Discussion of results

The above dimensions of the booster channel made it possible to reduce the distribution of impact force, thereby reducing costs and increasing productivity. When using dried healthy grains, the yield of the finished product was increased to 30-33%, and the yield of the decomposer increased to 150-200 kg of processed raw materials per hour.

A mixture of cores, unbreakable cores and shells from centrifugal stripping equipment enters the drum separators, where they are separated from each other. The seeds are wrapped in a loop, and the kernels come to pre-dry. As practice shows, such nuclei are harvested from 5 to 20-25% depending on the conditions of seed collection, processing, storage. After that, the commercial nuclei reach a humidity of less than 3% for washing and final drying. Dry kernels can be stored for a long time in the open air, without losing their marketable properties.

Experiments on the cleaning from the shell of Cedar grain on pneumatic jet stripping equipment were carried out and filled in Table 1. As a result of the experiment, it was observed that between an air speed of 42 m/s and 30 m/s, Cedar grains were peeled from their shells without disturbing the grain structure.

Table 1 – Experiment results on pneumatic jet stripping equipment

		Cedar grain sizes				
Experiment №		5mm	6mm	7mm	8mm	9mm
1	Air velocity, m/s	42 m/s	38 m/s	37 m/s	36 m/s	33 m/s
2		40 m/s	40 m/s	39 m/s	34 m/s	31 m/s
3		41 m/s	38 m/s	36 m/s	36 m/s	32 m/s
4		41 m/s	41 m/s	39 m/s	35 m/s	32 m/s
5		42 m/s	39 m/s	38 m/s	35 m/s	30 m/s

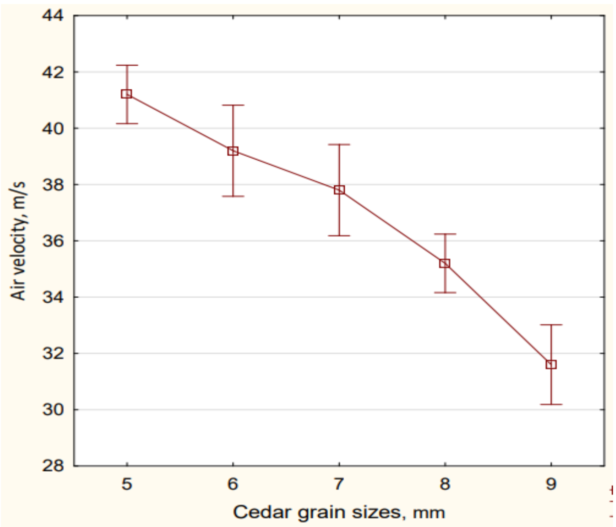

Figure 4 - The ratio of air velocity to grain diameter in pneumatic jet stripping equipment

Figure 4 shows the experiment results for the ratio of air velocity to grain diameter in pneumatic jet stripping equipment. The experiment shows at what air speed the grains peel, depending on their diameter , that is, 5 mm Cedar grains are reflected when struck at an air speed of 41 m/s, 6 mm – 39 m/s, 7 mm – 38 m/s, 8 mm-35 m/s, 9 mm-31 m/s.

In the first case, the results of the experiment showed that for successful cleaning of grain from the shell, a high air supply rate is required, but not more than 45 m/s and not less than 25 m/s, which is useful for optimizing the cleaning process.

Experiments were carried out on the equipment of centrifugal stripping of Cedar grain and filled in Table 2. As a result of the experiment, it was observed that between 18 N*m and 7 N*m of torque, Cedar grains are peeled from their shells without disturbing the grain structure.

Table 2 - Experiment results on centrifugal stripping equipment

		Cedar grain sizes				
Experiment №		5mm	6mm	7mm	8mm	9mm
1	Torque, N*m	16 N*m	14 N*m	12 N*m	11 N*m	9 N*m
2		14 N*m	15 N*m	11 N*m	9 N*m	7 N*m
3		18 N*m	16 N*m	13 N*m	10 N*m	8 N*m
4		15 N*m	16 N*m	14 N*m	9 N*m	7 N*m
5		17 N*m	15 N*m	14 N*m	9 N*m	8 N*m

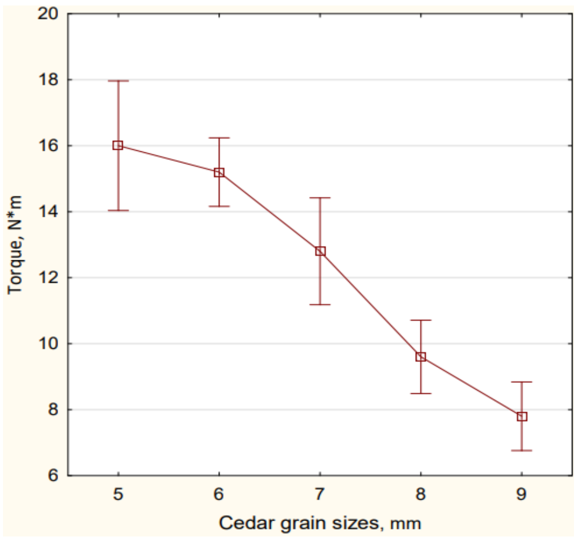

Figure 5 - The ratio of torque to grain diameter in centrifugal stripping equipment

Figure 5 shows the experiment results for the ratio of torque to grain diameter in Centrifugal stripping equipment. The experiment shows at what torque the disc peels, depending on the diameter of the grains, that is, 5 mm Cedar grains separate from the shell when hitting the target with a torque of 16 N*m, 6 mm – 15 N*m, 7 mm – 13 N*m, 8 mm-10 N*m, 9 mm - 8 N*m.

Numerous experiments have shown that the disadvantage of this method is the low yield of the finished product and the destruction of the grain structure. With an average grain weight without a shell of 43%, the yield was less than half of the specified number. We were able to eliminate losses using the shock method, which occurs when the detachment of the grain shell hits the target.

Conclusion

A technological scheme for the complex processing of cedar nuts has been developed, which includes the production of refined grains of Cedar nuts. It has been shown that optimal peeling conditions are achieved after drying and short-term moistening of nuts. As a result of the experiments performed, it was shown at what airspeed and with what torque grains of different sizes are peeled when hitting the target. In the course of semi-industrial experiments, it was found that among the tested types of Walnut peeling equipment, good results are achieved through the use of multi-channel centrifugal peeling equipment.

Conflicts of interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

CRediT author statement

A.H. Hamitbek: Reviewing and editing, software, **A.E. Kairbaeva:** Analysis of scientific research results, interpretation of results, **M.V. Kopylov:** Research, methodology, data processing

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Балқарағай жаңғағын қабығынан тазартуға арналған арнайы жабдықты әзірлеу бойынша эксперименттік зерттеулер

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Қабылданды: *10 мамыр 2024*

ТҮЙІНДЕМЕ

Зерттеу балқарағай жаңғағының дәнін зерттеуге және оларды өңдеу үшін арнайы пневматикалық реактивті және орталықтан тепкіш жабдықты қолдануға бағытталған. Жұмыстың негізгі мақсаты – балқарағай жаңғағын тазартуға арналған арнайы жабдықты әзірлеу. Мақалада Қазақстан Республикасының шығысында кең таралған балқарағай жаңғағы тұқымдарының ерекшеліктері сипатталған, сондай-ақ қарағай жаңғағы дәндерін алудың технологиялық схемасы ұсынылған. Балқарағай дәнінің ядроларын қабықтан зақымдамай бөлуге мүмкіндік беретін арнайы жабдықты әзірлеу нәтижелеріне назар аударылады. Осы жабдықтарда эксперименттер жүргізілді, олардың нәтижелері график түрінде ұсынылды. Зерттеулер нысанаға қарай бағытталған әртүрлі өлшемдегі дәндерді қабығынан тазарту үшін қандай ауа жылдамдығы мен айналу моменттері қолданылатынын көрсетті. Бірінші сынақта дәндер диаметріне қарай қабықтан қандай ауа жылдамдығымен тазартылатыны көрсетілген, яғни 5 мм-41 м/с, 6 мм – 39 м/с, 7 мм – 38 м/с, 8 мм -35 м/с, 9 мм-31 м/с ауа жылдамдығымен нысанаға соғылған кезде балқарағай дәндері қабықтан тазартылатыны көрсетілген. Екінші сынақта дәндердің диаметріне байланысты дискінің қандай айналу моментімен айналу керегі көрсетілген, яғни 5 мм-15 н * м, 7 мм-13 н * м, 8 мм-10 Н* м, 9 мм-8 Н*м айналу моментімен нысанаға соғылған кезде қабықтан тазартыланы көрсетілген.

Түйін сөздер: балқарағай жаңғағы, тазалау жабдығы, пневматикалық жабдық, орталықтан тепкіш жабдық, технологиялық схема

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Экспериментальные исследования по разработке специального оборудования для очистки кедровых орехов от скорлупы

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АННОТАЦИЯ
Исследование направлено на изучение семян кедрового ореха и применение специального пневматического реактивного и центробежного оборудования для их обработки. Основная цель работы заключается в разработке специального оборудования для очистки кедрового ореха. В статье описываются особенности семян кедрового ореха, которые широко распространены на востоке Республики Казахстан, а также представлена технологическая схема извлечения ядер кедрового ореха. Основное внимание уделено результатам разработки специального оборудования, которое позволяет отделить ядра кедрового зерна от оболочки без их повреждения. Проведены эксперименты на данном оборудовании, результаты которых были представлены в виде графиков. Исследования показали, какие скорости воздуха и крутящие моменты используются для выбрасывания зерен различного размера при воздействии на цель. В первом испытаниии показано, при какой скорости воздуха зерна очищаются от скорлупы в зависимости от их диаметра , то есть кедровые зерна очищаются от скорлупы при ударе по мишени со скоростью воздуха 5 мм-41 м/с, 6 мм – 39 м/с, 7 мм – 38 м/с, 8 мм-35 м/с, 9 мм-31 м/с. Во втором испытании показано, при каком крутящем моменте диска , в зависимости от диаметра зерен, то есть 5 мм – 15 Н*м, 7 мм – 13 н*м, 8 мм-10 Н*м, 9 мм - 8 Н*м при ударе по мишени с крутящим моментом очищаются от скорлупы.

Ключевые слова: *кедровый орех, оборудование для очистки, пневматическое оборудование, центробежное оборудование, технологическая схема*

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