REPUBLIC OF AZERBAIJAN

On the rights of the manuscript

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

IMPROVING OF THE TECHNOLOGY OF JUICES AND WINES WITH THE USE OF CRYOTHERAPY

Specialty: **3102.01 – Agroengineering**

Field of science: **Technical sciences**

Applicant: **Ragsana Gazanfar Aliyeva**

Ganja-2021

The work was performed at Azerbaijan State Agrarian University

Scientific supervisor: doctor of technical sciences, professor
Jamaladdin Alekber Mammadov

Official opponents: - doctor of technical sciences, professor
Bayram Mahammad Baghirov
- doctor of philosophy in technical sciences, associate professor
Afiq Gazanfar Masimov
- doctor of philosophy in technical sciences, associate professor
Elchin Mahammad Javadov

Dissertation Council at FD 2.26 of the Supreme Attestation Commission under the President of The Republic of Azerbaijan operating at Azerbaijan State Agrarian University

Chairman of the Dissertation: Council: doctor of technical sciences, associate professor
Tariyel Mahammad Panahov

Scientific secretary of the Dissertation council: doctor of philosophy in technical sciences, associate professor
Vugar Tofig Aghayev

Chairman of the scientific seminar: doctor of technical sciences, professor
Ziyad Mehrali Abbasov

GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. . The richness of the food structure of the country's population with such biologically valuable food products as meat, meat products, milk, dairy products, fish, fish products, eggs, vegetable fats, fruits is still below the level of medical standards.

An important place in the system of rational nutrition of the population is occupied by the problem of replacing fats and fat components obtained from animal products with vegetable components in the composition of prepared food. In this regard, it is convenient to use raw materials, including nuts, the biochemical composition of which is favorable. This product also contains 60 .. 65% of lipids, essential fatty acids, tocopherols and biologically valuable proteins.

When breeding valuable local and introduced varieties of nutmeg in the vast territories of the republic, with the state concern for the development of this industry, as well as with the increased interest of producers, you can see the presence in the country of great potential opportunities in the food industry and the manufacture of biologically active additives from this product. At the same time, it should be noted that the hazelnut kernel produced in Azerbaijan, being competitive in the foreign market in its qualities, is considered one of the priorities that bring currency to the country.

There are other reasons why using hazelnuts as a side dish in the food industry increases viability. Currently, the world is rapidly replacing balanced amino acid composition of animal proteins with limited plant-based ones. For this purpose, soy protein is almost the most used.

At the same time, it is known that soy is harmful to the human body. It was found that hydrolyzed soy protein impairs the brain activity and nervous system of children. In addition, soy has the ability to actively accumulate radioactive strontium, a dangerous radionuclide. It is from this point of view that we see that the opinion formed in the world practice that the food industry is dominated not by soy, but by watermelons, is changing in the direction of fruit. Not to mention the fact that the development of nut farming is possible

with the technical support of this industry. Currently, it is considered extremely important to ensure a high-quality clean, healthy, lossless grain yield both in agricultural conditions and in the processing industry.

In particular, the current issue was the elimination of difficulties with the peeling of fruits (30% of the kernels crumble) and the improvement of technology and technical means for the production of high-quality kernels.

Purpose and objectives of the study. Given the relevance of the issue, this research paper aims to substantiate the rational technological and technical parameters of the preparation of high-quality hazelnut kernels that meet the requirements of the food industry.

To achieve this goal, the following main research objectives are defined::

- study of the physical and mechanical properties of the kernel, bark and fruit cover of hazelnuts;
- development of theoretical considerations for the process of cleaning the core from the peel and fruit shell;
- development of a method for monitoring the physical and chemical parameters of raw materials and finished products (cores) ;
- preparation of technological, structural and energy parameters of the experimental plant for the production of hazelnut kernels;
- testing and determining the cost-effectiveness of an experimental plant for the production of walnut kernels in production conditions.

The physical – mechanical, physico – chemical and thermophysical properties of the fruit and the hazelnut kernel, the process of destruction of the hazelnut shell and purification of the nuclear shell, the device of experimental grinding of nuts were taken as the object of research.

The subject of the study is the design and operating parameters of the experimental crushing plant and nuclear coating cleaning, which ensure the production of a high-quality core.

Research methods. Theoretical studies were conducted using the laws and methods of classical mechanics and mathematics. Experimental studies were conducted on the basis of generally

accepted and specially developed methods using the theory of planning a multi-factor experiment in laboratory conditions in accordance with current standards. The results of the experiment were processed using mathematical statistics and computer reporting programs.

Scientific novelty of the research. The conditions of the destruc-tion of the hard shell of the nut and the separation of the thin shell forming the nuclear shell, as well as the factors affecting the fragility of the core and the level of purification of the thin shell as an indicator of quality, are justified by analytical dependencies. The design improvement of the working bodies and the technology of breaking drum-type nuts in terms of maximum pressing of the cores is performed at the level of the utility model (U20180019). On the basis of regression analysis, optimal estimates of the main operating parameters of an experimental drum-type wrench and a disk-type nuclear shell cleaning unit are justified.

Theoretical and practical significance of the study. The theoretical study of the mechanism of destruction of the nut shell, the construction of its mathematical model, the establishment of mathematical relationships between the quality of the core and the design and operating modes is of theoretical importance for the machine-building industry, specializing in processing machines, its research and development organizations in terms of improving the appropriate technical means.

The plant developed as a result of research for the preparation of hazelnut kernels with its optimized operating parameters, the resulting economic efficiency is of practical importance from the point of view of application for farms producing hazelnuts.

Approbation and application of works. The main provisions and results of the dissertation were presented at the 8th International Scientific and Practical Conference "Development of agricultural Science, International cooperation in the field of food security and environmental protection“ (Ganja, 2016)," Scientific and Practical Conference on the results of research work of ASAU employees in 2018, dedicated to the 96th anniversary of the birth of National

Leader Heydar Aliyev" (Ganja, 2019). The report and discussion were made.

The experimental walnut plant proposed as a result of the study was used in a farm in the Zakatala district and brought 6 thousand manats to the farm during the season. The results of the study were discussed at the scientific and Technical Council of the Azerbaijan State Agrarian University, approved and recommended for use in production. (Protocol No. 10, May 30, 2018).

Main provisions to be submitted for defense: The main provisions submitted for protection are as follows

❖the main physical, physico-mechanical, physico-chemical and thermophysical properties of the fruit of the local nut and its kernel;

❖linear mathematical model of the technological process of nut breakage;

❖analytical dependencies for the analysis of the failure mechanism for various shell designs;

❖justification of resources for improving existing structures for cleaning hard shells and nuclear coating of nuts;

❖design and technological features of the experimental drum-type wrench;

❖optimal pricing of operating mode parameters of experimental treatment and disk nuclear plants.

According to the dissertation, 7 scientific articles were published, 1 of which was published in the Russian Federation and one utility model was approved.

The name of the organization where the dissertation work is performed. The dissertation work was carried out at the department of “Mechanical Engineering and standardization” of the Azerbaijan State Agrarian University.

The total volume of the dissertation with an indication of the volume of the structural sections of the dissertation separately. The dissertation work consists of an introduction, four chapters, a conclusion, a list of references in the number of 152 and appendices. There are 46 figures, 19 tables and 7 appendices. The content of the dissertation contains an introduction of 6 pages and 11909 characters, the first chapter of 37 pages and 66071 characters, the

second chapter of 36 pages and 44154 characters, the third chapter of 20 pages and 32238 characters, the fourth chapter of 30 pages and 37752 characters, conclusions of 2 pages and 4059 characters, recommendations for production of 1 page and 1476 characters, References 152 pages and 25036 characters. The volume of the dissertation is 159 pages of computerized text, the total volume is 228802 characters (203758 characters excluding the list of references and appendices).

CONTENT OF THE WORK

In the introduction, the relevance of the topic, the problem statement and the general characteristics of the dissertation are given.

First chapter. This chapter is entitled "Problem statement, goals and objectives of the research" are reflected in the current trends in the development of nut fruit production in the world and Azerbaijan, the state of studying the consumer properties of nuts, the analysis of primary processing technologies, the criticism of devices that destroy the nut shell by mechanical action, the formation of design requirements for design, the theoretical study of the strength of coatings and the process of separating the shell. At the end of the chapter, the goals and objectives of the study are presented.

However, such a technological problem as the complete preservation of the core without damage (wiping) during the industrial processing of fruits containing the core, has not yet found its effective solution.

Peel cleaning in existing plants that break the peel of such fruits and separate the core 70 ... 80%. At this time, 20% of the cleaned cores are damaged. In this regard, it is of economic and social importance to improve the technologies and technical means of preparing hazelnut kernels in the direction of quality requirements both in the field of production and in the processing industry.

Second chapter is entitled It is called "Theoretical study of the process of cleaning the core from the shell and fruit shell", where the construction of a linear mathematical model of the technological process of destruction of the hazelnut shell, the study of the mechanism of destruction, the choice of an electric motor for the

installation for cleaning the hazelnut shell, the study of cleaning the shell of the hazelnut kernel by air flow is given.

As an object of research, an experimental drum device was developed on the basis of a working hypothesis, separating the core (core) of the hazelnut from the hard shell (fig.1.).

The device consists of a throttle consisting of an electric motor-1, a coupling-2, an infinite screw gearbox-3 and a belt drive-4, a drum that breaks the nut shell-5, a chain that separates the shell from the core-6, a board that removes the shell-7 and 8-a hopper with the nut shell. Here the role of the main working organ was assumed by the combination with the drum. To determine the dependencies between the parameters of the organ that splits the hazelnut shell, we use the report scheme (fig. 2.). It consists of a drum rotating at an angular velocity of ω, and a subframe. There is a certain gap between the D-diameter drum and the subframe. At this time, the cross - section of the nut of size ”b" will be affected by repulsive forces (drum – N_1 and subframe-N_2) perpendicular to the surfaces of the drum and subframe, and the friction forces F_1 and F_2 touching them. The actual reaction forces of the drum and subframe will be on the slope from the norm to the angle φ.

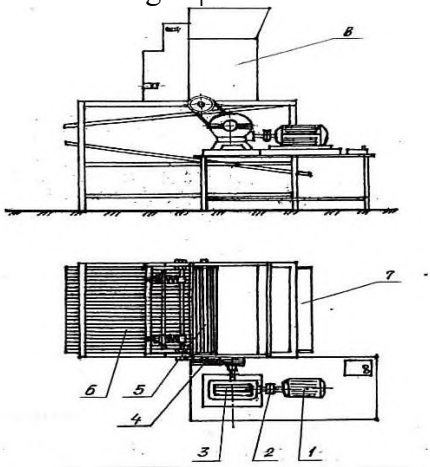

Figure 1. Experimental device that separates the hazelnut kernel from the shell: 1-electric engine; 2-coupling; 3-infinite screw gearbox; 4-belt drive; 5-drum that breaks the nut shell; 6-chain; 7-board that removes the shell, 8-hopper with the nut shell.

Here, when the surfaces have different materials and quality, the friction angles in the “hazelnut – drum” and “hazelnut – subframe " pairs will be different and will be equal to φ_1 and φ_2–, respectively.

Taking into account that an angle y is formed between the axes of the tangent perpendiculars, we can conclude that this angle characterizes the condition for the operability of the selected mechanism. In other words, the angle γ must be less than any angle of the friction cone ($2\varphi_1$ and $2\varphi_2$) in order for the hazelnut to be removed from the drum and subsequently broken.

Since the shape of the subframe is in the shape of a logarithmic spiral, it will be below the point "A" where the hazelnut touches the subframe.

To simplify the sheet, we take the hazelnut slice as a circle with a diameter of "d". The D_b -diameter drum rotates counterclockwise with ω_b-angular velocity.

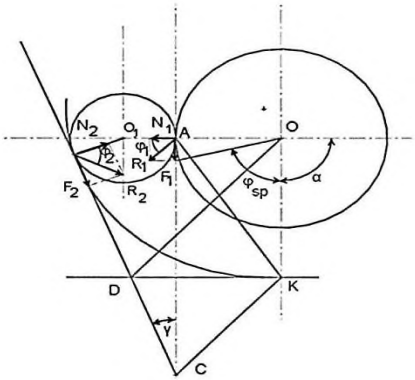

Figure 2. Diagram of the shell breaking report

Having calculated that the breakage of the hazelnut shell occurs at 900 revolutions of the drum, the restrictions on the technological interval are determined:

- the size "b" is determined by the size of the hazelnut;
- the size of "d" is determined by the size of the kernel;
- sizes”b“ and "d" are determined by the results of research.
- Banzer $\Delta\, DCK$ and $\Delta\, AKO$ are similar to the γ angle as follows:

$$\gamma = \pi - \alpha - \varphi_{SP} \quad (1)$$

where α - angle of rotation of the initial radius of the logarithmic spiral;

φ_{SP}– the angle between the initial radius of the logarithmic spiral and the tangent drawn to this point.

To determine the geometric dependencies, we will make a system of equations for the point "b". Thus, this point is common to both the hazelnut circle and the logarithmic spiral (subframe) (fig. 2).

We give the equation of a circle whose center is located at the point O_1 - from the common center to the center “O”.

where X_0 – distance between centers, $x_0 = \frac{D_b + d_f}{2}$

The equation of the logarithmic spiral in polar coordinates is as follows:

$$r = r_0 e^{k\alpha} \quad (2)$$

where r_0 - initial radius of the spiral

k – scale parameter

$$r_0 = \frac{D_b + d}{2} \quad (3)$$

$x_0 - in \;\; r_0 - a$ substituting the relation λ, that is $\frac{x_0}{r_0} = \lambda$ we get

$$k = \frac{\ln\frac{\lambda}{2}\cos\alpha}{\alpha} \quad (4)$$

$$k = ctg\varphi_{SP}$$

Thus, the conditions for the interaction of geometric parameters are obtained. They were used to determine the optimal size of the device designed to break the hazelnut shell.

It can be determined by projecting forces in the direction of the axis of the hazelnut that, without taking into account the deformation, the following condition must be met in order for the hazelnut to be taken by the drum with a break grip and removed:

$$F_1 \cos\alpha_1 + F_2 \cos\alpha_2 \geq N_1 \sin\alpha_1 + N_2 \sin\alpha_2 \quad (5)$$

so that,

$$F_1 = N_1 tg\varphi_1 \quad \text{və} \quad F_2 = N_2 tg\varphi_2 \quad (6)$$

where φ_1 *and* φ_2 – the drum and subframe are the angles of friction on the surface. We get their prices if we use them in the previous expression:

$$N_1 tg\varphi_1 \cos\alpha_1 + N_2 tg\varphi_2 \cos\alpha_2 \geq N_1 \sin\alpha_1 + N_2 \sin\alpha_2 \quad (7)$$

In this case, the triangles α_1 and α_2 can be taken as the same (α). So, the points of contact of the drum and the subframe with the hazelnut are determined by gravity and are located on a horizontal line. Hence also the condition that the hazelnuts must be caught and extracted in order to break is as follows:

$$tg\varphi_1 + tg\varphi_2 \geq 2tg\alpha \quad (8)$$

Otherwise, the process does not occur. In other words, if the diameter of the cross-section of the hazelnut is larger than the required size, characterized by the angles $\varphi_1 and\ \varphi_2$, they will be thrown out of the capture zone.

Taking into account the fact that the cross - section diameter strongly diverges depending on the size, the presence of additional protrusions on the drum increases the value of the angle α_1-increase to (while α_2 remains unchanged), that is, the friction angles $\varphi_1 and\ \varphi_2$decrease, significantly improving the conditions for holding the nut to feed it into the breakage process. In other words:

$$\text{tg}\ \varphi_1^1 + tg\varphi_2 \gg 2\left\{tg\alpha_1^1 + tg\frac{\alpha_2}{2}\right\} \quad (9)$$

α – the price of the angle depends on the geometric dimensions of the drum, the size of the cross-section of the hazelnut, the interval gap, the distance between the exact points of contact of the drum and the subframe with the hazelnut (a), that is, on the position at which the hazelnut is not clamped. From the reporting scheme (fig. 2) according to $\cos\alpha = \frac{2OA}{D}$

$$OA = \frac{D}{2} + \frac{a}{D} - \frac{b}{D} \quad (10)$$

because of this

$$\cos\alpha = 1 + \frac{a}{D} - \frac{b}{D} \quad (11)$$

Hence, the use of hazelnuts with a cross-section width ”b" in the process of reliable breaking is possible if the following conditions are met:

$$a \leq b - D\ (1 - \cos\varphi) \quad (12)$$

It follows from this inequality that the interval space is defined by the size "b".

With an increase in the intermediate gap to a certain value, the ability of the drum to introduce hazelnuts into the breakage process increases. But at this time, the hazelnut capture zone may have a

large arc size. This size should be like this. Let the hazelnuts crunch and serve to break the shell and separate the kernel.

The performance of the device that separates the hazelnut kernel from the shell, as can be seen from theoretical considerations, depends on the ability of the drum to capture the hazelnut and introduce it into the process. Here, the hazelnuts should be fed into the compression zone in equal order, avoiding knocking at the entrance to the working area.

The drum plays an important role in the design of the drum crusher. Therefore, it is necessary to analyze the design parameters. These parameters relate to the diameter of the drum, its length, width and wall thickness.

The length of the drum can be determined by the formula given by M. A. Berezin, G. T. Pavlovsky :

$$L = \frac{53\,Qa}{DZ\delta\varepsilon_y n} = \frac{2{,}7Qa}{Z\varepsilon_y v_b} \qquad (13)$$

where Q – installation capacity, kg/hour;

a – the presence of hazelnuts in the nests, %;

D – drum diameter, m (D = 2R);

Z -the number of slits falling on 1m^2 of the drum surface;

δ – drum wall thickness. m;

ε_y – socket surface utilization rate;

v_b – the speed of rotation of the drum, v_b=0,25 ... 0,8 m/s is accepted;

n – number of drum cycles, sec^{-1};

In these devices, the hazelnuts are directed to the surface of the rotating drum and, under their own weight, are lowered into the slot and transported to the breakage zone. Since the slots are conical in shape, with two open sides, they do not pass through the slot and move along with the drum to the clamping board. Here there is a need to select the shape and size of the drum slots in accordance with the shapes and sizes of the hazelnut variety grown in the zone. As for the number of slots, they should be determined depending on the required capacity, width and diameter of the drum.

The number of slots on the drum surface can be calculated using the following formula:

$$Z = \frac{4BD\varepsilon_b}{d^2} \quad (14)$$

where B – working width of the drum, m;

D – drum diameter, m;

ε_b – drum surface utilization factor;

d – the diameter of the hazelnut (it becomes equal to the diameter of the slot on the outer surface of the drum),m.

The drum surface utilization factor is determined as follows:

$$\varepsilon_b = \frac{S_{deş}}{S_y} = \frac{\pi d^2}{S_y} = 0{,}785 \quad (15)$$

where $S_{deş}$ – the area of the hole in the elementary slot (the area of the hole is selected according to the size of the hazelnut), m^2;

S_y – slot area, m^2;

We determine the area of the conical gap (S_y) as the area of the cone section:

$$S_y = (r_1 \cdot r_2)l \quad (16)$$

where r_1 – radius of the great circle of the cone, m;

r_2 – radius of the small circle of the cone, m;

l – the height of the slot (the distance between the centers of large and small circles), m;

Also taking into account the distance between the slots, the area required to place the slot can be calculated using the following formula:

$$S = \pi r^2 + k_э \quad (17)$$

where $k_э$ – additional coefficient ($k_э = 2 - 3$),

πr^2– the area of the circumference of the slot on the surface of the drum, corresponding to the size of the hazelnut,m^2;

The optimal step between the slots is as follows:

$$t = 2r + k_э^2$$

The diameter of the drum can be determined as follows:

$$D = \frac{4 \cdot \vartheta_b^2}{\pi^2} \quad (18)$$

where ϑ_b-drum rotation speed ($\vartheta_b = 0{,}25 - \frac{0{,}8m}{sec}$ accepted), m/sec.

Based on the received prices, you can choose a suitable pipe for the manufacture of a drum according to GOST 10704-91.

Drums for a slotted structure, the width of the drum surface can be determined from the condition of the size of the slits along the line:

$$B = \frac{n_y}{\pi\, D} \cdot t\,, \qquad (19)$$

where n_y – the number of nests in one row (depending on the performance, n_y=3...7 pieces,.) is accepted pcs.;

D - drum diameter, mm;

t – optimal problem between slots, mm.

The thickness of the drum can be determined by the formula:

$$\delta = \delta_k + C, \qquad (20)$$

where δ_k – the thickness of the drum wall, determined in accordance with the standards of the strength reportı, mm;

C - additional (technological and operational), C=2.

The strength standard and the reporting method are adopted in accordance with GOST 14249-89.

The design diagram of the disk-type organ is shown in figure 3.

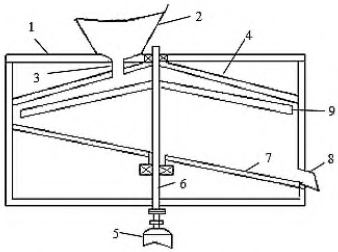

Figure 3 Design diagram of the hazelnut breaking disc type: 1-housing; 2-hopper; 3-pipe feeding the hazelnut; 4-conical disk; 5-electric motor; 6-shaft; 7-guide; 8-output branch; 9-rotating conical disk**.**

The device consists of a housing -1, a hopper for unbroken hazelnuts-2; a tube that brings the hazelnuts to the working bodies -3, a fixed conical disk-4; an electric engine -5; directing the broken

hazelnuts from the shaft to the output-an outlet pipe for extracting the processed product and a rotating conical disk located under the fixed conical disk. The diagram of the forces acting on the hazelnut during operation is similar to figure 4.

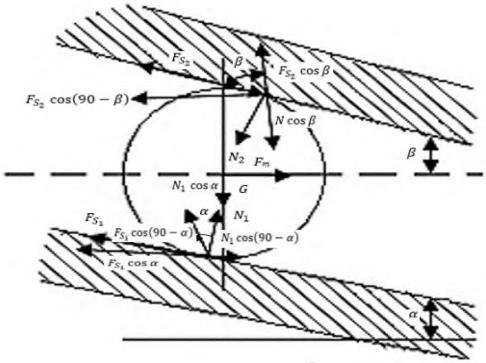

Figure 4. Diagram of the forces acting on the hazelnut:

F_S - the friction force from the surface of the active working body; F_{S2} - the friction force from the conical disk of the lid; N_1 - the force from the active working body; N_2- the force from the conical disk of the lid; F_M- the centrifugal force..

Fig. 4 according to the scheme, we write the equation of the action of forces on the X-axis as follows:

$$\sum F_x = 0; \tag{21}$$

$$F_M + N_1\cos(90-\alpha) - F_{S1}\cos\alpha - N_2\cos(90-\beta) - F_{S2}\cos(90-\beta) = 0$$

Hence express F_M:

$$F_M = F_{S1}\cos\alpha - N_1\cos(90-\alpha) + (N_2 + F_{S2})\cos(90-\beta) \tag{22}$$

We determine the friction force of the hazelnut, acting on the active working body during operation, as follows:

$$F_{S1} = N_1\frac{(k_{abr}+k_{met})}{2} \tag{23}$$

Where

k_{abr} −coefficient of friction of the seamless surface,$k_{abr} = 1{,}6$;

k_{met} − coefficient of friction of the metal surface, $k_{met} = 0{,}3$.

With this in mind, we can write

$$F_{S1} = N_1\frac{(1{,}6+0{,}3)}{2} = 0{,}95N_1 \tag{24}$$

And the friction force of the hazelnut, moving during operation from the side of the cap disk, is as follows:

$$F_{s2} = N_2 k_{met} = 0{,}3N_2 \quad (25)$$

if we use it in the formula, (24) and (22) we get:

$$F_M = 0{,}95N_1 - N_1 \cos(90 - \alpha) + (N_2 + 0{,}3N_2)\cos(90 - \beta) \quad (26)$$

if we do the conversion we can writeF_M the price as follows:

$$F_M = N_1(0{,}9\cos\alpha - \cos(90 - \alpha)) + 1{,}3N_2 \cos(90 - \beta) \quad (27)$$

If you consider that,

$$F_M = m_d r_d . \omega^2 \quad (28)$$

where $m_d -$ working disk weight, kg;

$r_d -$ working disk radius, m;

$\omega -$ pulse angle, sec^{-2}

Then, using the value F_M-in formula (28), we obtain the formula for the angular momentum of the working fluid of the active conical disk:

$$\omega^2 = \frac{N_1(0{,}95\cos\alpha - \cos(90 - \alpha) + 1{,}3N_2 \cos(90 - \beta)}{m_d r_d} \quad (29)$$

According to the condition of the breakage of the hazelnut shell N_1 and N_2, the sum of its vertices must be greater than the breakage force $N_1 = N_2$, if we take the conical formula that determines the angular momentum of the active working body (disk).

$$2N_1 \geq F_{böh} \quad (30)$$

That time

$$\omega^2 = \frac{1}{2}\frac{F_{böh}}{m_d r_d}[0{,}95\cos\alpha - \cos(90 - \alpha) + 1{,}3\cos(90 - \beta)] \quad (31)$$

Third chapter under the title ”Program and methodology of experimental research", where the research program is given, the justification of the working hypothesis as an object of research, the research methodology. Among the methods of analysis that have become widely used in assessing the quality and physico-chemical properties of food products for research, the method of planning a multi-factor experiment was used to optimize the main design and operating parameters of the studied processes and installations, and the method of mathematical statistics to ensure the integrity of the experimental estimates obtained.

Fourth chapter named "The results of experimental studies and their analysis". It defines the physical, technological, and physico – chemical, physico – mechanical, and thermophysical properties of hazelnuts, studies the destruction of the solid shell and the cleaning of the nuclear coating, optimizes the main technological parameters of experimental hazelnuts, and calculates the economic efficiency.

Breaking the hard shell of a hazelnut is considered the most responsible operation in the general technological plan. For farming, a simplified production line is used (fig. 4). After harvesting on the farm, the top-coated product, after drying under the sun in the open air, is cleaned and fed to the hazelnut crusher to break the hard shell and separate the core from the hard shell. To clean the kernels separated from the solid shell from the thin shell (core shell), they are dried with hot air to an air-conditioning humidity of 6%.

The kernels, dried to a conditioned humidity, are loaded into a feeding cord in a disk shell, and at the output, the core is obtained as the final product, cleaning it from the thin shell with a fan.

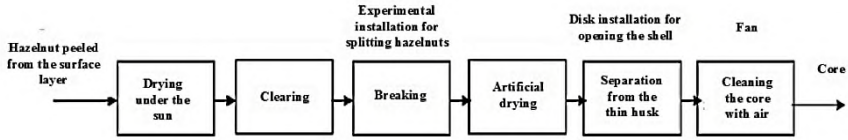

Figure 4. Simplified technological scheme for obtaining hazelnut kernels.

The purpose of this experiment was to study the basic laws of the influence of hazelnut moisture on its destructive power.

To obtain samples with different humidity, the hazelnuts were soaked in different amounts of water and then stored in sealed conditions for two, four, six and eight days. Of the two fractions of hazelnuts by size with the same number of nuts in each dish-12...16 mm small in diameter. Large hazelnuts with a diameter of 22 mm were used.

The humidity was determined based on the method of weighing and determining the mathematical expectation of the results. After determining the moisture content of the hazelnuts, they were tested for strength. The studies were carried out using the bench shown in chapter 3 and based on the methodology.

The results of changes in the moisture content of hazelnuts and the pressure that affects the fragility of the shell are shown in table 1 below.

Table 1. Prices reflecting the effect of hazelnut moisture on the pressure spent on the destruction of its shell

Large fractions					small fractions				
experiment number	weight, q		absorbed humidity,q	splitting pressure, MPa	experiment number	weight, q		absorbed humidity,q	splitting pressure, MPa
	before humidification, q	after humidification,q				before humidification, q	before humidification, q		
1	3,42	3,90	0,48	0,36	1	2,73	3,15	0,42	0,24
2	3,58	4,30	0,72	0,45	2	2,41	3,12	0,71	0,38
3	3,91	4,65	0,74	0,54	3	2,40	3,15	0,75	0,45
4	4,20	5,12	0,92	0,50	4	2,38	3,17	0,79	0,55

The stability of the tendency of the hazelnut shell to increase the breaking pressure with increasing humidity is established. The obtained estimates allow us to draw the following conclusions:

As the moisture content of the hazelnut increases, the gap between the kernel and the shell decreases. This makes it difficult to preserve the entire interior of the task at hand, i.e. the broken hazelnuts. When the humidity increases, the hazelnut shell needs more energy to break down. As a result of the research, it was possible to clarify the factors that affect the destruction of the core (filling) when peeling hazelnuts from the shell.

Thus, when processing hazelnuts in experimental hazelnuts, the drum rotation frequency, the size and humidity of the hazelnuts have the greatest influence on the parameters, which was confirmed by the experiment. The correlation – regression dependence between the parameters and the operating modes of the installation was established by the method of experiment planning. The plant capacity is 140 kg / hour; the output of all cores without damage is 94 %.

Results

1. Data on the biological and nutritional value of hazelnuts confirm that the kernel of this fruit is a source of full-fledged proteins, fats, vitamins and minerals. The chemical composition of hazelnuts with the presence of blackberries in the fruit shows that. their primary processing after collection should serve to preserve their completeness, in other words, to ensure the quality of products.

2. When the hard shell of the hazelnut breaks, the tissue may break away from the hazelnut core or the core may collapse. This event negatively affects the fat content, as well as the commercial quality of the gross product. On the other hand, simplifying the complex systems used in primary processing would reduce both the number of impacts on the product and the resulting costs.

3. The analysis of the results of theoretical studies shows that when the intermediate gap in the drum-type hazelnuts increases to a certain value, the ability of the drum to introduce the hazelnuts into the destruction process increases. But at this time, the hazelnut capture zone may have a large arc size. This size should be such that it serves to break off the hazelnut shells and separate the core. The performance of the device that separates the hazelnut core from the shell, as can be seen from theoretical considerations, depends on the ability of the drum to capture the hazelnut and introduce it into the process. To do this, the hazelnuts should be fed into the compression zone in equal order, avoiding knocking at the entrance to the working area.

4. Experimental hazelnut breaking the installation is improved by the fact that the pusher inside the drum is located evenly along the inner surface of the drum in the break zone, at a distance that does not participate in the break.

5. The study of the process of cleaning the nuclear coating in a disk-type device showed that with an increase in the radius of the active working disk by 100 mm-500 mm, the force required to separate the shell increases in a linear relationship. When the angle of inclination of the active working disk changes from 10 to 500, the force separating the shell increases in equal order. This force increases dramatically when the angle of inclination increases to 50-

900. And this can lead to a failure of the core. Therefore, the value of the tilt angle of the active working disk from 10 to 500 can be considered acceptable for a stable workflow.

6. This has been established through theoretical research. the movement of the shell during the cleaning of the nuclear shell by the air flow consists of rotation in equal order with an angular velocity ω_0–, cyclic moves with a constant frequency and angular amplitude. With an increase in the rate (ϑ) of separation of the thin shell from the total mass, its angular velocity and stroke frequency increase, and the amplitude decreases. $\omega_0^2 > 2\lambda\vartheta^2$, where the shell, making a complete revolution, creates a mass flow regardless of the angle of rotation of the head axis of the shell. Strengthening of the rotational movements of the shell in a periodic uneven air flow, the support of the shell particles on the trajectory by torsion. The massive body helps to enter the cyclone with the flow of air.

7. The correlation – regression relationship between the parameters and the operating modes of the installation was established by the method of experiment planning. Optimized technological parameters formed the basis for the technical characteristics of the developed experimental wrench: the plant capacity is 140 kg/hour; the yield of intact nuclear energy is 94 %.

8. The optimized parameters that ensure the complete stay of the core for cleaning the nuclear coating in the disk installation with laboratory experiments and a report are as follows: the rotation speed of the active working disk n = 57/2 min^{-1}; the minimum interval between the disks z = 17.95 mm; the created pressure P=13.4 kPa. The optimal values corresponding to the degree of cleaning of the core surface from the thin shell (97.8%) are in this limit, n = 620min^{-1}, z = 18 mm, P = 13 kPa.

9. Compared to the basic machine used in the farm with a seasonal output of 5 tons, the efficiency of the developed nut-cracker unit was 852.85 man, and the overall efficiency, taking into account the additional revenue from sales for quality, was 6077.85 man.

Recommendations for manufacturing

From the point of view of the maximum compliance of the hazelnut kernel with the demand for environmentally friendly

products, among all possible methods of their primary processing, it is proposed to give preference to the mechanical method without cleaning from the shell, including using the technology and technical means proposed in this research paper.

Based on the analysis of the obtained regression equations, it can be concluded that when the hazelnuts break, the damage to the core depends more on the moisture content of the hazelnuts. With an excess of moisture, it takes a lot of force to break the hard shell. Given that a large role in this process is played by moisture, pre-prepared, which will be susceptible to breakage of 12 to 14%, preferably before drying.

As a result of the study, the role of parameters that affect the economic efficiency of the process of grinding hazelnuts was determined. The project requirements are justified in order to reduce capital investment in special technical equipment, operating costs (including maintenance and maintenance costs) and minimize the negative impact on product quality.

The main provisions of the dissertation are reflected in the following published articles:

1. Alieva, R.G. Substantiation of the parameters of the installation for cleaning nuts from the shell // development of agrarian science, international cooperation in the field of food security and environmental protection. Materials of the 8th International Scientific and Practical Conference. - Ganja: ASAU, 2016, Vol. II. - pp. 258-260.

2. Alieva, R.G. Production of hazelnuts in the Sheki-Zagatala economic region // Baku: Azerbaijan agrarian science. - 2016. No. 2. - p.150-151.

3. Alieva, R. G. Experimental and statistical study of walnut shell destruction technology //Ganja: Ganja branch of the National Academy of Sciences of Azerbaijan, collection of news. – 2017, №2 (68), -p. 81-85.

4. Alieva, R.G. The choice of an electric motor for a hazelnut-shell cleaning plant // -Ganja: Ganja branch of the National Academy of Sciences of Azerbaijan, collection of news. – 2017, №3 (69), -p. 121-125.

5. Alieva, R.G. Separation of peeled hazelnut husks by air flow // - Moscow: Agrarian science. - 2017. № 11-12. pp. 27-29.

6. Alieva, R.G., Mammadov J.A. Investigation of the destruction of hazelnut shells // Ganja: Ganja branch of the National Academy of Sciences of Azerbaijan, collection of news.–2018,№2(72),-p.134-137.

7. Alieva, R. G. Walnut installation, utility model U20180019, Republic of Azerbaijan / Mammadov J.A. Khalilov R.T., 2019

8. Alieva, R.G. Theoretical study of the experimental rattlesnake // Ganja: Ganja branch of the National Academy of Sciences of Azerbaijan, collection of news. – 2019, №2 (76), -pp. 156-162.

9. Alieva, R.G. Investigation of the mechanism of destruction of the walnut shell // Materials of the scientific and practical conference on the results of scientific and research works of ASAU employees in 2018, dedicated to the 96th anniversary of the birth of National Leader Heydar Aliyev. Ganja: ASAU, 2019, pp. 53-55.

10. Alieva, R. G. Investigation of the cleaning of the coating of the walnut kernel // Azerbaijan Technological University, scientific news-Ganja: - 2020, No. 2/33, pp. 27-32.

11. Mammadov, J.A., Alieva, R.G. Resources of constructive and technological improvement of the installation for splitting the hazelnut shell//72nd International scientific and practical conference "Promising technologies in the modern agro-industrial complex of Russia: traditions and innovations". - Ryazan, - 20 April 2021, - pp.62 - 67

12. Alieva, R.G. Determination of dependencies between the parameters of the working bodies of the hazelnut shell husker // Technical sciences: problems and solutions. Collection of articles based on the materials of the XLVIII International Scientific and Practical conference. - M., Publishing House "Internauka", - May 2021. No. 5(44) - pp.68-76.

13. Mammadov, J.A., Alieva,R.G. Study of the physıcal, technologıcal and physıco-chemıcal characterıstıcs of hazelnuts // journal "Bulletin of science and practice" 2021, No.6, - pp. 87-95.

The defense of the dissertation will be held on «***24***» ***September*** 2021, at ***14^{00}*** at the meeting of the Dissertation council FD 2.26 of Supreme Attestation Commission under the Azerbaijan State Agrarian University.

Adress: Az 2000, Azerbaijan Republic, Ganja city, 450, Ataturk avenue.

Dissertation is accessible at the Azerbaijan State Agrarian University library.

Electronic versions of the dissertation and its abstract are avaialable on the official website of the Azerbaijan State Agrarian University

Abstract was sent to the required addresses on **«** ***06*** » ***July*** 2021.

Signed for printing:30.06.2021
Paper format: (210x297) 1\4
Volume: 37214 characters
Number of hard copies: 30