Electric Pulse Processing in the Extraction of Oil from Industrial Seeds

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Abstract: This article investigates energy-efficient electrotechnology for the extraction of cottonseed oil from industrial seeds. Growing global demand for cottonseed oil necessitates technologies that enhance oil yield while minimizing energy consumption. This study applies electric pulse processing as a primary treatment method to improve oil quantity and quality, reducing technological losses and energy costs. A comparative review of mechanical, chemical, and electrophysical extraction methods is presented, highlighting the advantages of electrotechnological approaches. Experimental results demonstrate that electric pulse processing significantly increases damage to oil-retaining seed tissues and cells. Optimal processing parameters were identified: discharge voltage of 6 kV, capacitor capacitance of 0.8 µF, 18 pulses, seed pulp moisture of 9%, and material thickness of 10 mm. Under these conditions, cellular damage reaches 80–85%, enabling oil yield to increase by 4.5–5% compared to conventional technology. Additionally, the roasting temperature can be reduced from 105–110°C to 70–75°C, resulting in 35% energy savings. A regression model describing the relationship between processing parameters and the degree of cellular damage was developed and validated. Production-scale trials at Tashkent Oil Plant JSC confirmed the technical feasibility and economic viability of the proposed technology, yielding annual savings of approximately 1.2 billion soums.

Keywords: Cottonseed oil extraction, Electric pulse processing, Energy efficiency, Seed tissue damage, Oil yield optimization.

1 Introduction

At present time the creation of highly efficient technology and technical means for the process of obtaining oil by primary processing of cotton seeds is considered relevant. "Every year, 23 million tons of raw cotton are grown, 30-35% of seeds and 5.5 million tons. Considering that more than one ton of oil is obtained," the development and implementation of energy-saving methods and technical means in the process of obtaining oil from seeds is of great importance. Due to the growing demand for cottonseed oil around the world, special attention is paid to meeting the demand for high-quality petroleum products and at the same time using energy-efficient modern technologies and tools in oil production [1].

As prices for energy resources rise, the issue of energy saving at production enterprises becomes more urgent. Since the main part of the cost of the product in oil producing enterprises is the cost of energy, accounting for 96% of the total energy balance, in order to improve production technology, increase the quantity and quality of oil obtained from the seed, as well as reduce technological losses and energy costs, electrotechnological products are applied to the product. Primary processing with using the method and developing a technical tool that implements it, conducting research activities aimed at development is becoming increasingly important.

Due to the high relative energy costs per unit of oil and petroleum products, large-scale measures are being implemented to gradually provide the oil industry with modern, highly efficient equipment and new energy-efficient technology. The world is committed to further strengthening food safety and producing environmentally friendly products. In particular, "modernization and technical re-equipment of enterprises in the cotton and oil and oil industries, the introduction of modern effective technologies and developments that ensure improved quality of cotton products, cotton oil and oil and oil products" are identified as one of the important issues. One of the most important issues in implementing these tasks, accelerating the production of cottonseed oil from industrial seeds and achieving energy efficiency in the field of oil production is the practical application of modern equipment and technologies.

2 Materials and Methods

The development of efficient technologies for cottonseed oil extraction has been the subject of extensive research by both international and Uzbek scientists. International contributions include the work of V.G. Shcherbakov, A.M. Goldovsky, V.M. Kopeikovsky, S.I. Danilchuk, G.I. Garbuzova, B.E. Kirievsky, P.P. Demchenko, V.V. Klyuchkin, R.D. Breen, S.R. Gregory, E. Hernandez, B.R. Savoy, J.T. Cothren, L.A. Jones, S.S. King, and P.J. Vaklian. Within Uzbekistan, significant contributions have been made by I.I. Mehmanov, Kh.F. Juraev, T.R. Shomuradov, K.Kh. Gafurov, D.Sh. Bazarbaeva, Yu.A. Saidmuratov, Z. Salimov, A. Sabirov, A.Yu. Usmanov, K.O. Dodaev, P.Kh. Yuldashev, A.A. Artikov, A.F. Safarov, A.Kh. Mamatkulov, K.P. Serkaeva, and A. Elchiev, among others. These studies cover mechanical, chemical, and electrophysical primary processing methods, as reviewed below.

To speed up the extraction of oil from oilseed products, primary processing can be divided into 3 main methods. These include grinding and compression of the product, i.e. mechanical processing, chemical processing with water, polar and non-polar solvents, enzymes and enzymes, as well as processing methods with electric current, electromagnetic field and other electrophysical influences.

Scientific research on the development of methods and technology of mechanical oil production and their results [2-4] in the works of scientists, scientific research on the use of the effects of water and polar solvents in increasing the efficiency of oil production [5, 6] in the works of scientists various enzymes and scientific research on accelerating the efficiency of oil extraction using the influence of drugs [7, 8] in the works of scientists, scientific research on accelerating the process of oil extraction using the effect of non-polar solvents on petroleum products [9-11] in the works of scientists, the use of electrophysical effects in increasing the efficiency of oil production is positive. The research results [12-14] are presented in detail in the works of scientists.

In particular, V.M. Kopeikovsky, S.I. Danilchuk, G.I. As a result of scientific research, when pumpkin seeds are crushed with mechanical devices, the processed cell walls and oil should be released freely. The product is processed with hot steam and heat treatment. The degree of grinding determines the production of products and improving the quality of the product produced [15].

Kirievsky B.E., Demchenko P.P., Klyuchkin V.V. established that as a result of two scientific experiments with oil, the following changes were revealed when treated with water and heat. Processed improvements include increased volume, shell flexibility, other additives, modifications and reservoirs. Therefore, the internal pressure of the cell increases, and the level of damage at which the membrane on the cell surface can collapse is average. In addition, the heat applied to the dirt reduces the viscosity of the oil, which clearly improves the extraction of oil during pressing [16].

A. M. According to Goldovsky's assumption, based on his scientific research, it was mentioned that it is possible to completely damage cells and tissues by grinding oil products in a roller grinding device. [3]. But V.G. Shcherbakov’s conclusions, based on his scientific research, stated that it is impossible to completely damage the cells and tissues of the product with a roller crushing device. The reason for this is the very small cell size of oilseed products. The size of the seed cell is 33.5 × 17.5 μm, that of the soybean seed is 75.0 × 24.4 μm, and that of the sunflower kernel is 45.5 × 30.0 μm. Long-term exposure to water and heat on the processed product leads to a deterioration in the quality of the oil of the resulting finished product [8].

To speed up the extraction of vegetable oil from oilseeds and preserve important elements in the finished product, a number of researchers have conducted research into other methods of extracting vegetable oil.

In particular, V.G. In Shcherbakov's research, it was possible to obtain 76% pistachio oil from sunflower and 20% cottonseed oil from cottonseed oil by treating the product with water and polar solvents. However, when processing products with water using this method, intense hydrolysis of lipids occurs and activation of the enzyme system of oilseeds occurs. Most importantly, the product must be heat treated to remove the water content. This leads to deterioration in the quality of important useful elements in the finished product, as well as to excessive energy consumption [8].

One of the physicochemical methods for obtaining vegetable oil, which has been developing in recent years, is pressing and extraction of vegetable oils with non-polar organic solvents. The reason why vegetable oil extraction by direct extraction from oilseeds is not widely used today in oil and fat enterprises is due to the imperfect design of all types of extraction devices.

Melting oil using the extraction method requires 1.2-1.3 times more costs than squeezing oil by pressing.

Beloborodov V.V., Klyuchkin V.B., Usmanov R., Mamatkulov M.M. and other scientists have used various solvents to speed up the extraction of vegetable oil. [18-20].

L.I. Goltsova’s research obtained positive results on the extraction of oil from plant seeds using the electro-hydraulic method. At the same time, he used the extraction feature of the electrohydraulic effect. According to its technological scheme, cotton seed enters the processing chamber with water flowing from the pipe, and as a result of passing through the discharge gap between the electrodes, the oil contained in the product is then released [21].

Salimov Z. used an alternating magnetic field to accelerate oil extraction by direct extraction of cotton pulp with various solvents. This, in turn, made it possible to speed up the time of oil extraction from the seed pulp by 1.5-3.0 times [22, 23].

Safarov A.F. By treating seeds with an electromagnetic field, compared to treatment with water and heat, it was possible to accelerate the process of destruction of the structure of the seed cell by 7-9 times and improve the quality of pressed oil by 20-25% [24].

2.1 Materials

Experiments were conducted using cottonseed pulp (kernel extract) prepared from four cotton varieties cultivated in Uzbekistan: "Sultan," "Porlok," "Namangan," and "C65-24." Seeds were obtained from the Tashkent Oil Plant JSC (Tashkent, Uzbekistan) and classified into quality grades II, III, and IV according to the standard Uzbek oil industry classification. Seeds were pre-cleaned mechanically to remove mineral and organic impurities (measured as a percentage of total mass), dehulled, and the kernel extract (pulp) was separated for processing. Moisture content of the pulp was adjusted to target levels (6–14%) by controlled drying or humidification and verified gravimetrically (drying at 105°C to constant mass). Pulp samples were formed into flat layers of controlled thickness (5–15 mm) for placement in the processing chamber. Each experimental condition was tested in triplicate ($n = 3$), and mean values with standard deviation are reported.

2.2 Electric Pulse Processing Device

A laboratory-scale electric pulse processing unit was developed and used for all experiments. The device consists of a high-voltage capacitor bank (capacitance range 0.2–2.0 μF), a high-voltage DC power supply (0–10 kV), a spark-gap discharge switch, and a flat-plate stainless steel electrode chamber (electrode area 100 × 150 mm). The distance between the electrodes was adjustable to accommodate different pulp layer thicknesses (5–15 mm). Discharge voltage (U) was measured with a high-voltage probe and digital oscilloscope. The number of pulses (n) was controlled by a pulse counter and timing circuit. The energy stored per pulse was calculated as $W_k = ½CU^2$. The electrode gap was set equal to the thickness of the processed pulp layer (h), ensuring direct contact between the electrodes and the material surface without air gaps. All laboratory experiments were conducted at room temperature (20 ± 2°C).

2.3 Experimental Design

A five-factor, five-level rotatable central composite design (Box–Wilson method) was employed to optimize the electric pulse treatment parameters and derive the regression model. The five independent variables and their experimental ranges were: discharge voltage U (3–9 kV), number of pulses n (6–30), capacitor capacitance C (0.2–1.4 μF), pulp moisture content f (6–14%), and pulp layer thickness h (5–15 mm). Each factor was varied at five coded levels (−2, −1, 0, +1, +2), with the central point (0) corresponding to U = 6 kV, n = 18, C = 0.8 μF, f = 9%, h = 10 mm. The full experimental matrix comprised 50 runs, including 32 factorial points, 10 star points, and 8 centre-point replicates. The response variable was the degree of damage to oil-retaining tissues and cells (S, %), determined as described in Section 2.4. Regression coefficients were estimated by the method of least squares and the statistical significance of each coefficient was evaluated by Student's t-test ($p < 0.05$). The adequacy of the fitted model was confirmed by Fisher's F-test.

2.4 Measurement of the Degree of Cellular Damage

The degree of damage to oil-retaining tissues and cells (S, %) was determined by the electrical conductivity method, following the approach established by Vakhidov [17]. The specific electrical conductivity (γ^c, S/m) of the pulp was measured before and after electric pulse treatment using a conductivity meter at a probe frequency of 1 kHz. The degree of damage was calculated from the ratio of the measured conductivity to the maximum conductivity of fully disintegrated tissue, expressed as a percentage. Oil yield (%, mass fraction of extracted oil relative to total seed oil content) was determined gravimetrically after cold pressing at a standardised pressure of 35 MPa using a laboratory screw press. Residual oil content in the press cake was measured by Soxhlet solvent extraction with n-hexane. All measurements were performed in triplicate and results are presented as mean ± standard deviation (SD).

2.5 Production-Scale Trial

To validate the laboratory findings under industrial conditions, a production-scale trial was conducted at the central laboratory of Tashkent Oil Plant JSC. Seed batches of four cotton varieties (Sultan, Porlok, Namangan, C65-24) at quality grades II, III, and IV were processed using the electric pulse technological device designed according to the specifications derived from laboratory optimisation. For each seed batch, the following parameters were recorded: grade classification, mineral and organic impurity content (%), moisture content (%), applied discharge voltage (kV), pulse operating time (s), seed oiliness (%), residual oil in the press cake (%), and total oil yield (%). Results were compared against the plant's baseline performance under conventional mechanical-thermal processing technology. Energy consumption per tonne of crude oil was calculated for both technologies by summing the measured power inputs of each processing stage (cleaning, moistening, dehulling, hull separation, crushing, roasting, and pressing) at the production scale.

3 Results and Discussion

In these studies, certain positive results have been achieved in terms of creating new methods for obtaining cottonseed oil from industrial seeds, treating seeds with primary mechanical, chemical and electrophysical effects, increasing the quantity and quality of the resulting oil by selecting their optimal modes and parameters and achieving energy efficiency. However, these studies did not examine the issues of increasing the amount of cottonseed oil and achieving energy efficiency by destroying the tissues and cells of the seed that resist the release of oil by electrophysical influence.

When determining the relationship between changes in the level of damage to plant cells and the law of electric pulse processing, it is necessary to determine the relationship between the main factors of electric pulse processing (U, C, n) and the indicators of electric pulse processing degree of material damage C.[25]

In his research, O.Kh.Vakhidov determined the equations for the process of electric pulse processing of plant raw materials (fruit grains) in water, that is, he described the degree of damage during electric pulse processing of plant raw materials as follows:

$$S = S_0 e^{\left[-\frac{(W_k - W_c)\cdot n}{K}\right]} + S_m \left[1 - e^{\left[-\frac{(W_k - W_c)\cdot n}{K}\right]}\right] \quad (1)$$

Here: S_o and S_m initial and maximum value of the level of damage to plant material; n - number of pulses, units; K_i - coefficient characterizing the decrease in the destructive effect in the subsequent impulse compared to the previous one; Wk – energy stored in the capacitor; Wc – energy passing through the volume of the product.

$$W_k = \frac{1}{2} \cdot CU^2 ; \quad (2)$$

$$W_c = \int_0^T \frac{\delta^2(t)}{\gamma_c} dt = \frac{E_0^2 \cdot \gamma_c \cdot T}{2}\left(1 - \frac{1}{e^2}\right) , \quad (3)$$

Here: δ – electric current density; γc is the specific electrical conductivity of the processed product; T - constant discharge time.

$$\delta(t) = \delta_0 \cdot e^{-\frac{t}{T}} \text{ and } \delta_0 = E_0 \cdot \gamma_c , \quad (4)$$

Here: E_0 – electric field strength; t—discharge time.

Summarizing expressions (1,2,3), the level of damage to cells of legumes and fruits is expressed as follows:

$$S = S_0 e^{\frac{n}{K}\left(0{,}87 E_0^2 \gamma_c \cdot T - CU^2\right)} + S_m \left[1 - e^{\frac{n}{K}\left(0{,}87 E_0^2 \gamma_c \cdot T - CU^2\right)}\right] . \quad (5)$$

From this expression it is clear that the degree of damage to legume cells by electric pulse treatment before treatment is equal to the discharge voltage - (U), capacitor capacitance - (S), specific electrical conductivity of the product - (γ_c), electric field strength - (E_0), constant discharge time - (T) and number of pulses - (n).

The E-electric field strength in expression 5 for dielectric materials depends on (U) the applied voltage and (h) the distance between the electrodes:

$$E = \frac{U}{h} \text{ .; V/m,} \tag{6}$$

In this case, the distance h between the electrodes depends on the thickness of the workpiece.

Taking this into account. Expression 5, which determines the level of cell damage used by, A.Kh.Vakhidov, can be written as follows:

$$S = S_0 e^{\frac{n\cdot f}{K\cdot h}\left(E_0^2\gamma_c^*\cdot T - CU^2\right)} + S_m\left[1 - e^{\frac{n\cdot f}{K\cdot h}\left(E_0^2\gamma_c^*\cdot T - CU^2\right)}\right], \tag{7}$$

here S_o and S_m where and are the initial and maximum values of the level of damage to plant material; K_i - the coefficient characterizing the reduction in the damaging effect of the subsequent pulse compared to the previous one depends on the number of pulses and the type of product being processed. It has been established that for seed seed extract it varies within the range of K_i 0.35-0.52; *f* - humidity level of the processed product, %; h – thickness of the processed product.

From this expression it is known that the oiliness of the kernel extract depends on the degree of damage to the tissue holding the oil (U), the capacitance of the capacitor (C) and the number of pulses (n).

This theoretical expression characterizes the effectiveness of electric pulse treatment before extracting oil from the seed pulp.

The main factors reflecting the impact of electrical pulses were: discharge voltage (U), capacitor capacity (C), number of pulses (n), seed pulp moisture (f) and thickness of the processed product (h). To assess the effectiveness of electric pulse treatment of seed pulp and the characteristics of the treated product, the degree of damage to oil-retaining tissue and cells (S) was determined.

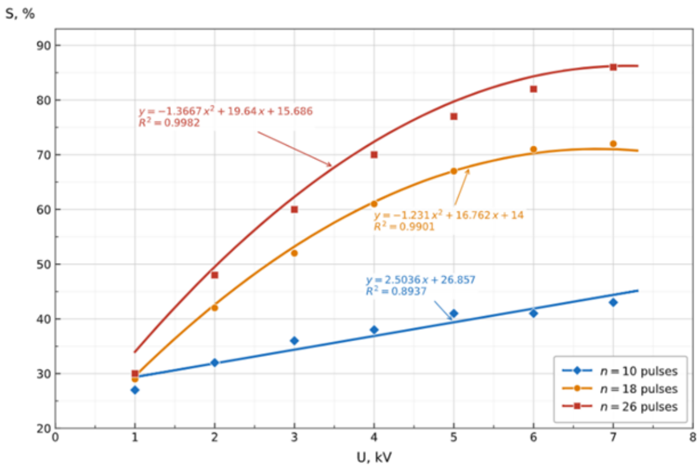


Figure 1

Figure 1. Effect of pulse discharge voltage on the degree of damage to oil-retaining tissues of cottonseed pulp (capacitor capacitance C = 0.8 μF, number of pulses n = 18, pulp moisture f = 9%, material thickness h = 10 mm). Source: authors' experimental data.

From the analysis of the curves in the given graph (Figure 1), the following was established. When the discharge voltage applied to the product increases to 6 kV, the degree of damage to the oil-retaining tissues in the seed pulp increases. The damage effect does not change as the voltage continues to increase. When the discharge voltage reaches 6 kV, the electric pulse treatment stops at 80-85% of the degree of damage to the cellular tissue of the seed pulp.

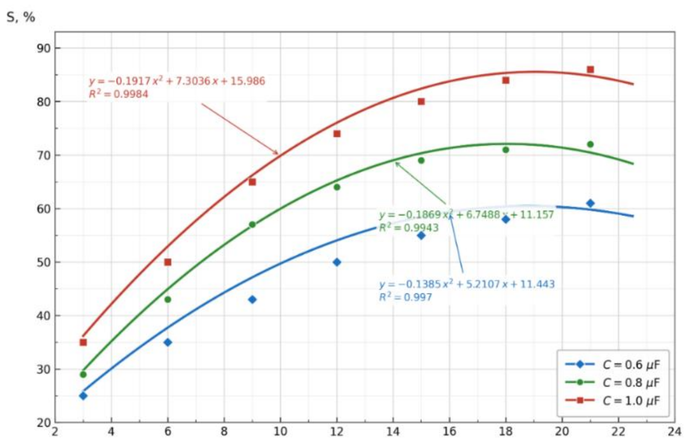


Figure 2

Figure 2. Effect of the number of electric pulses on the degree of damage to oil-retaining tissues of cottonseed pulp (U = 6 kV, C = 0.8 μF, f = 9%, h = 10 mm). Source: authors' experimental data.

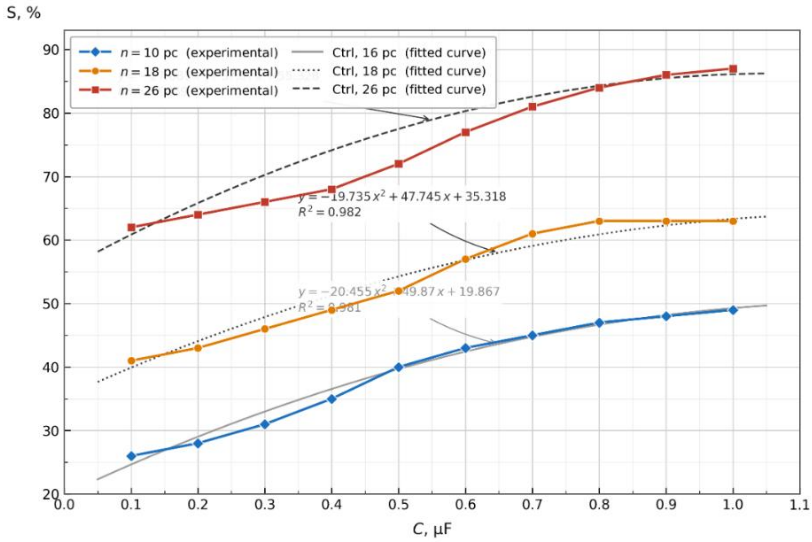


Figure 3

Figure 3. Effect of capacitor capacitance on the degree of damage to oil-retaining tissues of cottonseed pulp (U = 6 kV, n = 18, f = 9%, h = 10 mm). Source: authors' experimental data.

From the results of the experiment, it became clear that with an increase in the number of pulses supplied to the product, the level of cell damage sharply increases. When the number of pulses exceeds 18-20 units, the damage level becomes constant. Increasing the number of pulses from 18-20 units does not affect the level of damage and, on the contrary, leads to excessive energy consumption (Figure 2).

During the experiments, it was found that a capacitor capacity of 0.8 μF during electric pulse treatment is enough to damage the oil-containing cellular tissue of the seed pulp by 80-85%. When the capacitor capacitance increases from 0.8 μF, the degree of damage to cellular tissue does not change (Figure 3).

While using electric pulse processing of oilseed products, the thickness of the processed pulp is of great importance. According to the results of the experiment, the degree of damage to tissues and cells that retain oil is 80-85% with a seed layer thickness of 9-10 mm. Increasing the thickness of the workpiece leads to a decrease in the level of damage (Figure 4).

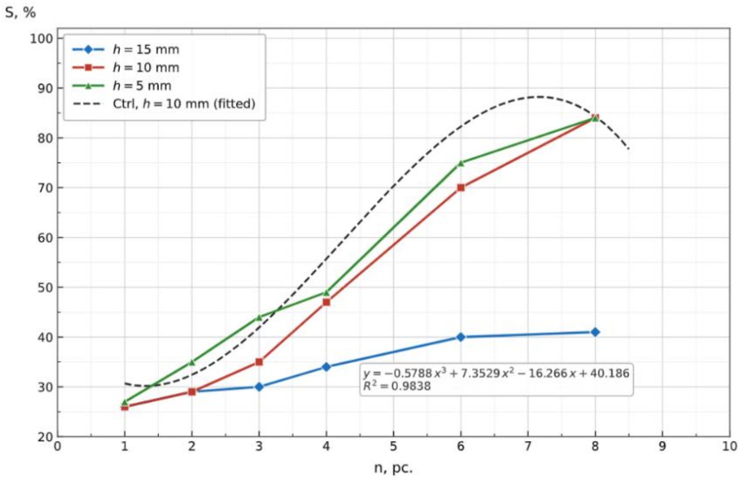
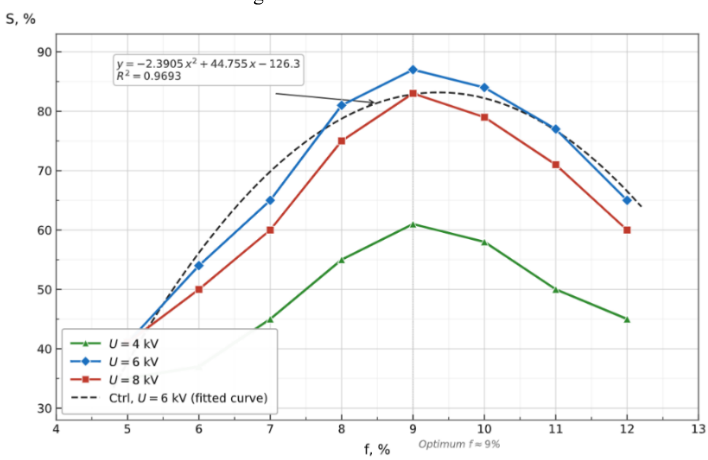


Figure 4

Figure 4. Effect of material thickness on the de



gree of damage to oil-retaining tissues of cottonseed pulp during electric pulse treatment (U = 6 kV, C = 0.8 μF, n = 18, f = 9%). Note: axis labels on curves indicate pulse number series. Source: authors' experimental data.

From the graphic curves obtained from the results of experiments, it is known that the degree of damage to oil-containing tissues contained in the product during electric pulse treatment is highest when the product humidity is 9-10%. Increasing product moisture content above 10% reduces tissue and cellular damage (Figure 5).

Figure 5

Figure 5. Effect of seed pulp moisture content on the degree of damage to oil-retaining tissues during electric pulse treatment (U = 6 kV, C = 0.8 μF, n = 18, h = 10 mm). Note: axis labels on curves indicate pulse number series. Source: authors' experimental data.

From research results it is known that after electric pulse treatment of seed pulp, the amount of oil released increases to 17% when the roasting temperature reaches 70-75°C. In this case, 70-75°C is needed to reduce the viscosity of the oil. With a subsequent increase in temperature, the amount of oil output does not change (Figure 6).

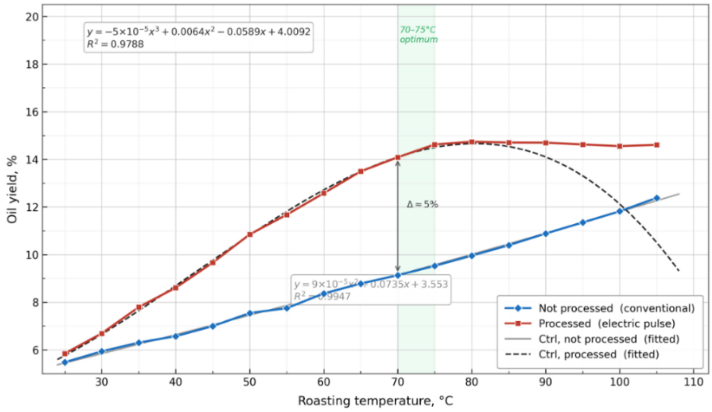


Figure 6

Figure 6. Effect of roasting temperature on oil yield (%) during pressing of electrically pulse-treated cottonseed pulp (U = 6 kV, C = 0.8 μF, n = 18, f = 9%, h = 10 mm). Source: authors' experimental data.

In practice, when frying, the temperature of the product is increased to 105-110°C, extra energy can be saved by lowering the roasting temperature of the seed pulp.

The experimental results obtained show that the more damaged the cells and tissues that retain oil in the seed pulp are, the greater the amount of oil is released (Figure 7).

According to the current technology, during mechanical and thermal treatment of the seed core, 45-50% damage to the oil-retaining tissues in the product is achieved, and the amount of oil yield is 11-12%. With electric pulse treatment, the degree of damage can be increased to 80-85%, which means the amount of oil yield can be increased to 16-17% (Figure 7).

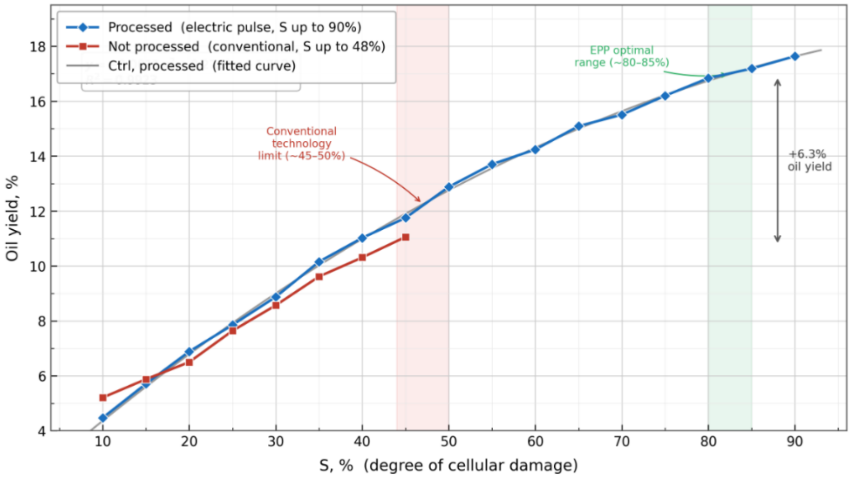


Figure 7

Graph of the degree of damage to oil release during the pressing of seed pulp treated with electric pulses.

A mathematical model representing the process of oil extraction by electric pulse processing of seed kernel extract is obtained using a second-order rotatable central composite design (Box–Wilson method). The model was derived from a full factorial experiment with five independent variables: discharge voltage (U, kV), number of pulses (n), capacitor capacitance (C, μF), seed pulp moisture content (f, %), and material thickness (h, mm). Each factor was varied at five coded levels (−2, −1, 0, +1, +2). The response variable was the degree of damage to oil-retaining tissues (S, %). Regression coefficients were estimated by the method of least squares, and the adequacy of the model was confirmed by Fisher's F-test ($p < 0.05$). The resulting regression equation (Expression 8) is:

$$\begin{aligned} S = {} & 35{,}78 + 1{,}6 \cdot U^2 + 1{,}03 \cdot n^2 + 35{,}55 \cdot C^2 + 2.15 \cdot f^2 + 1{,}78 \cdot h^2 - 2{,}84 \cdot U - 3{,}84 \cdot n - \\ & -297{,}7 \cdot C - 9{,}92 \cdot f + 0{,}04 \cdot U \cdot n - 3{,}82 \cdot U \cdot C - 0{,}11 \cdot U \cdot f - 0{,}01 \cdot U \cdot h + 2{,}39 \cdot n \cdot C + \\ & +0{,}07 \cdot n \cdot f + 0{,}08 \cdot n \cdot h - 2{,}8 \cdot C \cdot f + 2{,}75 \cdot C \cdot h + 0{,}03 \cdot f \cdot h \end{aligned} \tag{8}$$

According to the results of regression and variance analysis of the mathematical model, all coefficients are statistically significant at the 95% confidence level, and the model adequately describes the experimental data (Fisher's F-test, $p < 0.05$). The coefficient of determination $R^2 = 0.97$ indicates that the model explains 97% of the variance in the degree of cellular damage.

Based on the results of the experiment, the following optimal parameters for the level of damage to oil-retaining tissues (S_{opt}) during electrical treatment of oil extract from industrial seeds were determined: voltage of the fuel-treated discharge

6 kV, number of pulses 18, capacitor capacity 0.8 μF, fuel humidity 9%; allows you to increase the volume of oil extraction and save energy when the thickness of the processed material is 10 mm.

Based on the above results obtained in laboratory conditions, a technical specification was developed for the design of an electric pulse technological device for extracting cottonseed oil from industrial seeds.

Table 1 presents the results of studies conducted to test the technological regime and parameters for obtaining cottonseed oil from industrial seeds by electric pulse processing under production conditions at the oil extraction plant of Tashkent Oil Plant JSC.

To conduct experiments under production conditions in the central laboratory of the Tashkent Oil and Oil Plant, the structural parameters of industrial seeds were analyzed.

As can be seen from Table 1, the residual oil in the pulp after extracting the pressed oil from the pulsated seed pulp is 3-4%. This makes it possible to extract 4.5-5% more oil during the pressing process compared to existing technology.

Cost-effectiveness indicators were determined based on tests conducted under production conditions. Economic efficiency indicators were calculated using existing production technology and electropulse processing technology before pressing the seed mass.

Table 1.

While processing technical seed extract with electrical impulses influence on the oil production process.

№	Date	Indicators of the processed product		Indicators of the processed product		Parameters of the electric pulse		Output indicator of the total oil yield:, %
	Class of seeds prepared for processing	Mineral and organic compounds, %	Moisture content % Voltage	kV Operating time,	Service validity, sec.	Seed oiliness, %	Amount of oil remaining in the pot, %	
Cotton seeds of “Sultan” variety.								
1	II	1,195	8.5	6	12	20.5	3.362	17.138
2	III	1,324	9.2	6	13	17.3	3.148	14.152
3	IV	1.953	9.7	6	15	16.1	3.484	12.616
Cotton seeds of “Porlok” variety.								
1	II	1,143	8.4	6	12	21.1	3.244	17.865
2	III	1.531	8.8	6	13	18.6	3.39	15.21
3	IV	2.013	9.1	6	15	16.7	4.785	11.915
Cotton seeds of “Namangan” variety								

№	Date	Indicators of the processed product		Indicators of the processed product		Parameters of the electric pulse		Output indicator of the total oil yield:, %
	Class of seeds prepared for processing	Mineral and organic compounds, %	Moisture content % Voltage	kV Operating time,	Service validity, sec.	Seed oiliness, %	Amount of oil remaining in the pot, %	
1	II	1,155	8.7	6	12	20.1	3.176	16.924
2	III	1.629	9.1	6	13	18.4	3.529	14.871
3	IV	1.983	9.5	6	15	15.9	4.057	11.843
Cotton seeds of “C65-24”								
1	II	1,301	8.5	6	12	21.0	3.105	17.895
2	III	1.714	8.7	6	13	19.2	2.97	16.23
3	IV	2.473	9.3	6	15	17.2	2.873	14.327

Cost-effectiveness indicators were determined based on tests conducted under production conditions. Economic efficiency indicators were calculated using existing production technology and electropulse processing technology before pressing the seed mass.

The total comparative energy consumption for the production of 1 ton of oil using the current technology and the proposed technology has been determined. In the following expressions, W denotes specific energy consumption (kWh/t), where the subscripts refer to individual processing stages: “clean” — seed cleaning; “moist” — moistening; “bit” — seed dehulling; “sep” — hull separation; “crush” — seed crushing; “roast” — roasting of seed pulp; “press” — oil pressing. Subscript 1 refers to values for the existing (conventional) technology, and subscript 2 refers to values for the proposed electropulse technology. Wtot1 and Wtot2 denote total specific energy consumption (kWh/t) for the two technologies respectively.

$$W_{\mathrm{tot1}} = W_{\mathrm{clean1}} + W_{\mathrm{moist1}} + W_{bit1} + W_{sep1} + W_{crush1} + W_{\mathrm{tot.\ roast.1}} + W_{\mathrm{press1}} + W_{\mathrm{roast1}} = 34{,}27 + 42{,}50 + $$
$$+82{,}5 + 46{,}59 + 62{,}6 + 48{,}19 + 97{,}3 + 56{,}47 = 470{,}42\,\frac{kWt*h}{t}$$

$$W_{\mathrm{tot2}} = W_{\mathrm{clean2}} + W_{\mathrm{moist2}} + W_{bit2} + W_{sep2} + W_{crush2} + W_{\mathrm{tot.roast.2}} + W_{\mathrm{press2}} + W_{\mathrm{roast2}} = 24{,}19 + 30 + $$
$$+58{,}23 + 32{,}89 + 15 + 34{,}63 + 69{,}93 + 40{,}59 = 305{,}46\,\frac{kWt*h}{t}$$

The difference in the relative energy consumption to produce 1 ton of raw cottonseed oil using the current and proposed technology.

$$\Delta W = W_1 - W_2 = 470{,}42 - 305{,}46 = 164{,}96\,\frac{kWt*h}{t}.$$

While using electric pulse processing of technical seed mass, the relative energy costs for obtaining 1 ton of unrefined cottonseed oil are saved by 35%, the amount of oil extracted from the seeds increases by 4.5-5%.

The annual production capacity of Tashkent Oil and Oil Plant JSC is 94.5 thousand tons. Compared to the technology used at oil-producing enterprises with electric pulse processing of seed pulp, in the process of press-laboratory oil extraction an additional 50 kg of oil is extracted from 1 ton of seeds.

While producing 1 ton of cottonseed oil, which is obtained by electric pulse processing of seed pulp during the production of cottonseed oil, 169.96 kWh of electricity is saved, and depending on the annual volume, 2,730,407.4 kWh of electricity is saved. productive capacity. If we take into account the cost of electricity at today's tariff (450 soums), then 1,228,683,330 soums will be saved.

According to the analysis of technical and economic indicators, by reducing electricity consumption by 35% through the use of the proposed electropulse processing technology in the production of cottonseed oil, savings of 1,228,683,330 soums will be achieved. If 2,300,000 soums are subtracted from this profit, then the expected annual economic efficiency will be 1,205,683,330 soums..

Conclusions

Based on the results of research conducted on the topic “Energy-efficient electrotechnology for the extraction of cottonseed oil” the following conclusions were presented:

1) The state and prospects for the development of technologies for obtaining cottonseed oil from industrial seeds and the prospects for the development of technological processes of their work have made it possible to improve the technology for obtaining cottonseed oil from seeds and to develop equipment used in its implementation.

2) In the process of extracting cottonseed oil from industrial seeds, electric pulse treatment of the seed extract made it possible to significantly increase the level of damage to seed tissues and cells compared to other electrophysical effects.

3) It has been established that it is possible to achieve adequate damage to seed tissues and cells during electric pulse treatment of seed pulp with optimal values of discharge voltage, capacitor capacity, number of pulses, product humidity and thickness of the processed product.

4) While extracting oil from industrial seeds, a high-level of damage to oil-retaining tissues is achieved by electrical treatment of the seed pulp, at a discharge voltage of 6 kV, number of pulses 18, capacitor capacity 0.8 μF., pulp moisture 9%, thickness 10 mm.

5) Maximum damage to fat-retaining tissues in the product during electric pulse processing ensures a reduction in energy consumption compared to the

amount of oil obtained when the temperature is lowered from 100-105°C to 70-75°C during the next frying process.

6) While using the technical technology for producing cottonseed oil and a device created for its implementation in the production process, compared with existing technology, the oil yield increases by 4.5-5%, and the energy consumption for the production of cottonseed oil is reduced by 35%, and achieving an economic effect in the amount of 1,205,683,330 soums became possible.

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