Effects of electric pulse processing in increasing the efficiency of cotton oil from technical seeds

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Abstract. This article provides an analysis of the global demand for cottonseed oil consumption, the growing trend of cottonseed oil production and methods of obtaining vegetable oil based on modern technologies. Based on the results of the analysis, the electro technology of electric pulse processing of seed pulp was proposed to increase the efficiency of obtaining cottonseed oil from technical seeds. Experiments have shown that the maximum degree of damage to the seed nucleus by electric pulse treatment depends on the amount of oil extraction. It is also possible to reduce the roasting temperature of electrically pulsed seed pulp to 70-75 °C, and these parameters are considered be energy-saving parameters. It is possible to increase the amount of oil extracted from the seed and reduce energy costs in the technology through electro-pulse processing.

1. Introduction
The world produced 5.7 million tons of cottonseed oil in 2019, despite the fact that the volume of cotton production in 2019 decreased by 3% compared to 2018. This is 2.7% more than last year. Due to the growing demand for cottonseed oil in the world, it is important today to meet the demand of the population for quality oilseeds and energy efficient use of oilseeds. Continuing the growth trend of cottonseed oil production over the next 6 years, the production of cottonseed oil will reach 6.3 million tons by the end of 2025, and special attention is paid to improving the quality of the oil produced. As of 2019, the countries that consume the most cottonseed oil are India (1.6 million tons), China (1.4 million tons) and Pakistan (470,000 tons), which accounted for 62% of world cotton oil
consumption. The next places are occupied by Brazil, Australia, Uzbekistan, Turkey, USA, Burkina Faso and Myanmar, with a share of 25%, while the countries with the highest per capita consumption of cottonseed oil are Australia (10,839 kg per 1,000 people), Uzbekistan (1,000 7,845 kg per person) and Burkina Faso (4,923 kg per 1,000 people) [1].

Taking into account the fact that the country has the second highest consumption of cottonseed oil per capita in the world, the provision of the population with environmentally friendly oils is one of the tasks of the Republican state policy [2]. President of the Republic of Uzbekistan Sh.M. Mirziyoyev's Resolution No: PQ-4118 of 16.01.2019 "On additional measures for the further development of the oil industry and the introduction of market mechanisms in the management of the industry" provides for further strengthening of food security, production of environmentally friendly products. In particular, the modernization and re-equipment of enterprises of the cotton and oil industry, the introduction of modern effective technologies and scientific developments that will improve the quality of cotton products, cottonseed oil and oil products is one of the important issues [3].

According to the above analysis, in addition to increasing the amount of oil extracted from technical seeds produced in oil and gas enterprises, there is a problem of achieving energy efficiency and the need for scientific research in this regard.

2. Methods

Currently, there are 2 methods of obtaining vegetable oil on the basis of modern technology: mechanical compression of the oil, the method of pressing, and melting in a light volatile organic solvent, the method of extraction. These two methods can be used separately or together depending on the type and quality of raw material being processed. Oil extraction is carried out in a specific technological mode according to a separate technological scheme [4, 5].

Depending on the method of obtaining vegetable oil, production technological schemes are divided into two main groups: schemes completed by pressing and extraction. Technological processes, in turn, consist of basic, preparatory, auxiliary and additional operations [6, 7].

Figure 1 shows the technological scheme of the organic connection of the main, preparatory, secondary and additional processes.

The results of the analysis of existing technologies for the extraction of cottonseed oil in oilseeds show that the extraction of cottonseed oil from technical seeds requires improvement of the processes of grinding, roasting and pressing oil. Because these processes are the most energy-intensive processes in the production of cottonseed oil, these processes have a negative impact on product productivity and quality indicators [8, 9, 10]. Numerous studies have been conducted in our country and abroad to reduce energy consumption and increase efficiency in the production of vegetable oil. In particular, V.M. Kopeykovskiy, S.I. Danilchuk, G.I. It is known that the process of water vapor treatment depends on
temperature and thermal conductivity. Temperature and thermal conductivity depend on how much the product is crushed [11]. Salimov Z. The cotton mill used an alternating magnetic field to accelerate direct extraction with various solvents. This allows you to speed up the oil separation process by 1.5-3.0 times [7]. Safarov A.F. by treating the seed with an electromagnetic field, it was able to accelerate the process of breaking the structure of the seed cell by 7-9 times compared to water and heat treatment and improve the quality of the pressed oil by 20-25% [12]. Although these studies have been able to extract more of the oil in the seed, improving the quality of the oil obtained, high energy efficiency has not been achieved.

**Figure 1.** Technological scheme of oilseed production from cotton seeds

3. **Solving style**
Research in recent years has shown that drying fruits and melons, increasing the amount of juice obtained by electric pulse processing in extracting juice from them, and achieving energy efficiency [13,14,15].

Based on the above, a scientific hypothesis has been put forward and a number of experiments have been carried out that high efficiency can be achieved by electric pulse treatment of seed pulp in the extraction of cottonseed oil from technical seed to damage the adipose tissue in the technical seed cell.

4. **Outcome analysis and examples**
In the first experiments, the value of each discharge voltage (U) from 4 kV to 8 kV, the number of pulses (n) from 10 to 26, the capacitor capacitance (S) from 0.6 μF to 1 μF during the electric pulse treatment of technical seed pulp. The moisture content (f) of the machined grinding was studied from 6% to 12%, and the thickness of the machined grinding (h) from 5 mm to 15 mm. The following parameters were determined for the maximum degree of damage to the tissues holding the oil in the seed pulp during the oil extraction process by electric pulse treatment of technical seed pulp. Electric pulse discharge voltage 6 kV, number of
pulses 18, capacitor capacity 0.8 mkF, crushing humidity 9%; machined grinding thickness 10 mm. After electric pulse treatment of the seed pulp, the amount of oil output was checked by the pressing method [16,17].

From the results obtained, it can be determined that the higher the degree of damage to the seed pulp, the more oil can be extracted during the pressing process. When treated with electric pulses, 90-95% of the fat-retaining tissue in the product is damaged and the amount of oil leakage increases to 17.2%. When the seed is crushed by mechanical means, 45-50% of the fat-retaining tissue in the product is damaged. The oil yield is 11-12%. Therefore, all the studies that have been conducted so far have focused on damaging the fat-retaining tissues in the seed kernel to accelerate the process of fat extraction. Figure 2 shows the dependence of the oil output on the degree of damage during the compression of an electrically pulsed seed pulp.

![Figure 2. Dependence of oil output on the degree of damage during the pressing of electrically pulsed seed pulp](image)

Nowadays, it is not possible to extract oil from cotton seeds without heating the product. This is because the May grains in the seed pulp are in a solid gel state [18,19]. When the dough is heated, the temperature of the oil in it rises, which accelerates the movement of the oil. This leads to a decrease in viscosity. However, until the temperature is 50-60°C, the viscosity decreases for a while, and then this decrease slows down. Thus, the effect of heat is that the grind reduces the contact of the oil with the gel part, allowing the oil to separate (easily) and flow out. According to the current technology, the frying temperature of the product is brought to 105-1100S. This temperature leads to deterioration of the quality of the extracted oil and excessive energy consumption [20]. Figure 3 shows a graph of the dependence of the oil output on the frying temperature during the compression of an electrically pulsed mill.
It is known from the research results that after the electric pulse processing of the seed pulp, the roasting temperature rises to 17-7% when the oil comes out 70-75°C. In this case, to reduce the viscosity of the oil, a temperature of 70-75°C is needed. The amount of oil discharged does not change the next time the temperature rises. In practice, during the roasting process, the product temperature rises to 105-110°C.

**Figure 3.** Graph of the dependence of the oil output on the frying temperature during the compression of the electrically pulsed machining

\begin{align*}
y &= -0.0002x^3 + 0.0304x^2 - 1.2519x + 24.553 \\
R^2 &= 0.9753
\end{align*}

\begin{align*}
y &= 4.9359\ln(x) - 11.148 \\
R^2 &= 0.9474
\end{align*}

**Figure 4.** Laboratory device for extracting oil from technical seeds by pressing: 1) electric motor, 2) clutch, 3) RT type 40/1 reducer, 4) semi-clutch, 5) processor, 6) pressure regulator
The increase in the amount of oil discharged from the seed pulp with an electric pulse was tested by the pressing method. For this, a special press was prepared. Figure 4 shows an experimental apparatus for extracting oil by compression. The results of experiments on the extraction of oil from the technical seed pulp by the method of pressing after the application of an electric pulse are given in Figure 5.

Figure 4. Oil samples obtained by pressing the seed pulp after electric pulse treatment

5. Conclusions
The separation of fat from technical seed kernels depends on the viscosity, elasticity, and other properties of the fat-holding tissue in the seed cell. The more damage is done to the fat-holding tissue in the cell as a result of the initial treatment, the greater the oil output. By pulse treatment, the oil recovery rate can be increased to 4.5-5% by damaging the seed cell by 90-95%. Due to the maximum damage to the fat-retaining tissue in the product by electric pulse treatment of the mince, the temperature is reduced from 100-105°C to 70-75°C during the subsequent frying process. The resulting oil is able to improve its quality and maintain its nutritional value.

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