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Pulsed Electrical Discharge and Pulsed Electric Field Treatment during Sunflower Seed Processing

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Abstract

For the successful implementation of emerging electrical technologies in the oil pressing process, optimization of process parameters in combination with parameters from electrical process is crucial. The aim of this study was to evaluate the effect of the following pretreatments: pulsed electrical discharge (PED) and pulsed electric field (PEF) on rheological properties, morphological capillary-porous structure, and oil recovery of sunflower seed. FESEM analysis of the surface microstructure, pressing, and solvent extraction were used to obtain treatment efficiency after novel technologies. The results of this study show that PED and PEF treatments could be used as a pretreatment before sunflower seed processing to modify internal structure, increase the oil yield, or contribute to the mechanical destruction of oil globules and the release of free oil to the surface under gentle conditions.

Keywords: pulsed electric field, electrical discharge, crop, oil, oilseeds, processing, pressing, extraction, biofuel

1. Introduction

Sunflower oil production is rapidly emerging in Russia, Ukraine, Turkey, and other countries, filling an important niche of locally supplied protein and fat sources. Sunflower seeds are becoming of outmost importance to fulfill the requirements for safe products and find efficient ways to reduce potential chemical and technological hazards. Current methods of sunflower seed processing rely on well-developed and established food industry thermal treatment (roasting, drying, heating, and cooling), mechanical treatment (cleaning, flaking, grinding, and pressing), and fractionation methods (extraction, sedimentation, separation, centrifugation, etc.) [1–4]. Application of novel emerging processing technologies, which potentially can improve processing efficiency and quality of the products to the sunflower seeds, is rather limited.

Development of a novel scientific direction should be based on an active implementation of green technologies [5]. Green technologies include methods that enhance the efficiency of extraction of target components (oils, fats, phospholipids, polyphenols, pigments, etc.) from plant materials and can improve the traditional processing technology or combine traditional technology with novel emerging technologies [5].

Sunflower oil is a high-calorie product that is widely used in its natural form for food, canning, and cosmetic production purposes [6]. Sunflower oil is attracting increasing attention as a source of renewable raw materials for chemical and energy industries. The range of its use for chemical purposes is extremely wide—from use as a starting material for chemical synthesis to use as lubricants. Sunflower oil is more environmentally friendly: it decomposes after 7 days by 95%, whereas mineral oil decomposes only by 15–17%. As a biodiesel fuel, sunflower oil can partially replace natural oil reserves, reducing CO₂ emission [7]. Sunflower is one of the main crops used for biofuel production. An additional raw material during sunflower processing is sunflower husk, which is actively introduced as fuel pellets in alternative energy [8, 9].

Recently some promising emerging technologies of electrical treatment such as pulsed electric field (PEF) and high-voltage electrical discharges (HVED) for oil production were reported by several authors [10, 11]. As a novel industry-scale technology, pulsed electric field has already been mentioned as an innovative solution for electroporation of oil cells [12, 13] during extraction process. Permeabilization of the oil cell membrane can be increased due to rectangular bipolar or monopolar electrical pulses (millisecond or even microsecond pulse width). During volumetric PEF treatment, micro- and nano-pores are formed [14]. Such gentle treatment with low-temperature effects is quite important for heat-sensitive and organic materials. For oilseeds this technology forms an intercellular component film on the surface of treated materials due to electroporation [15]. This effect is studied by our research group and has great potential in oil extraction process.

To release the oil from the solid seed matrix, at a preparation stage, flaking, crushing, and roasting are used. According to [16] more than 40% sunflower spherosomes remain undestroyed after crushing and roasting. This limits a residual oil yield in sunflower meal. PEF or PED pretreatment assists in releasing the oil from lipo-vacuoles of mesocarp cells that have not been disrupted. Depending on process conditions (possibility of soaking or wetting of treating mass), PEF or PED treatment is preferred.

In order to expand the scope of application of PED and PEF treatments on an industrial scale, a clear understanding of the changes in the internal material structure, rheological behavior, processing efficiency, and extraction kinetics is necessary.

2. Pulsed electrical discharge treatment

As a novel technology, pulsed electrical discharge (PED) treatment has already been mentioned as innovative solution for electroporation of oil cells [10, 11, 15] during extraction process. The oil cell membrane can be charged sufficiently using monopolar electrical pulses (millisecond or even microsecond pulse width) to cause the rapid dielectric breakdown of material tissue under focused discharge energy. The main result of PED treatment is micro- and nano-channel formation [17] with low-temperature effects, which is quite important for heat-sensitive materials. For oilseeds this technology forms an intercellular oil film on the surface of treated materials due to electroporation [15]. This effect is studied by our research group and has great potential in oil extraction process.

Pilot-scale PED treatment set-up is described in **Figure 1a**. Pulsed electrical discharges were distributed to the treating mass in a filamentary glow discharge mode. Treatment chamber was in a point-plane electrode configuration. A stainless steel sphere (10 mm in diameter) was connected to a permanent magnet to

Figure 1. Experimental set-up used to generate pulsed electrical discharges in air (a), schematic visualization of treatment trajectory in a treatment cell (b), and visualization of a treatment process (c) (adopted from [18]).

focus discharges. Top and bottom electrodes were placed in a dielectric holder. The electrode gap was set as 15 mm. Treatment chamber was set on positioning platform with two stepper motors. Sunflower mass treatment trajectory was controlled by the authors' software in accordance with **Figure 1b**. Immediately after PED treatment, sunflower mass was transfer for pressing step.

In Advanced Technologies Lab (Krasnodar, Russia), PED treatment was performed using the Matsusada power high-voltage system in combination with high-voltage amplifier [18]. In the set-up used in these experiments, the pulse or discharge duration was of 10 μ s, and the frequency was 30 Hz. Each pulse or discharge applied provides a voltage of 30 kV. Specific input energy ranged from 10.0 J/kg up to 1.0 kJ/kg (**Figure 1c**).

The nature of the applied discharge in the treatment is shown in **Figure 1**. The high-voltage discharge oscillogram (**Figure 2**) is shown as two signals (purple and yellow). The yellow line characterizes the input signal coming to the amplifier and has distortion on the increasing front of the forward-angle pulse. The purple signal characterizes the output discharge on the electrodes. In this case, the microprobe on the falling edge of the rectangular signal in the form of repeated exponential pulses is clearly visible. These pulses characterize the presence of a breakdown in the air, visually observed during the experiment.

2.1 PED treatment effect on seed structure

Crushing and roasting are industrial technological steps assisting to release the oil from solid seed matrix, but not totally. To analyze the effect of PED treatment, treated sample was covered with gold and analyzed on FESEM. When analyzing the micrographs of the seed cake surface after roasting and PED treatment, an oil

film (F) is clearly visible, and electrical holes (H), expressed in the form of convex craters, less than 2 microns in size are noticeable (**Figure 3c**). PED pretreatment assists in releasing the oil from lipo-vacuoles of mesocarp cells that have not been disrupted. After sunflower seed cake roasting operation (110°C), globules of oil (O) are clearly visible in the dark and light areas, as well as an oil film (F), expressed in the form of light homogeneous areas (**Figure 3b**). FESEM images of PED-treated sunflower seed cake are shown in **Figure 3**. The oil cell membrane (M) is presented in the form of looped light fibers surrounding the oil cell (**Figure 3a, b**). At rest the pulp there is a loose coagulation structure. The adhesion between the dispersed particles occurs mainly due to the free oil released as a result of roasting process. Thus, the contacting particles of the seed cake form a skeleton in a fixed oily film, adhered to the walls of the screw channel.

Figure 2.
Waveform of the input signal coming to the amplifier (yellow) and the output high-voltage signal coming to the electrodes (purple).

Figure 3.
SEM image of initial (a) and heat moisture-treated sunflower seed cake (b) and FESEM image of heat moisture-treated plus PED-treated sunflower seed cake at x250 and x600 magnification (adopted from [18]).

2.2 Rheological properties of sunflower seed mesh after PED treatment

Studying the pulsed electrical discharge effect on rheological behavior of sunflower seed cake can help to advance work and to develop projects for their industrial application. Few authors reported positive effects on rheological properties on some oil crops [19, 20]. Positive effects of electric discharges on rheological behavior of material with high viscosity are reported by several authors [21, 22]. It means that electrical treatment process can modify internal seed structure, increase the amount of destroyed spherosomes, and change rheological parameters of seed cake.

Structurally sunflower seed cake is a complicated dispersed system consisting of dispersed phase bubbles, oil globules with husk droplets, and dispersed medium as a protein shell (**Figure 3**). Such dispersed systems usually are non-Newtonian and characterized by complex rheological behavior.

Each individual pulsed discharge develops according to filamentary glow discharge mechanism. With a large surface resistance of the dielectric material (sunflower cake), a charge is created on its surface, created both during the charge drift from the discharge zone of the gas gap and as a result of the surface discharge. Electrical discharges penetrate the sunflower seed mass causing the crater appearance in a treatment zone. As a focused electrical discharge, energy forms a channel and damages cell membranes.

When analyzing SEM images and considering the supplied pulse, discrete traces of surface discharges can be noted. The size of the craters remaining on the test material averages 3–10 μm (**Figure 3c**). It is important to note that for discharge with a “positive” voltage, they do not merge with each other, which indicates the same sign of the electric charge distributed over their body.

Considering the duration of the development of plasma-chemical processes, the speed of ions in an electric field, and the diffusion of chemically active compounds, the processing time of the material was determined to be minimal in terms of product quality. The maximum number of destroyed cell membranes and the maximum release of free oil to the surface were observed when exposed to a maximum number of pulses.

Using a modified rotational viscometer Fungilab One Pro (Fungilab, Spain) for sunflower mass, an apparent viscosity via shear rate dependence was obtained. **Figure 4** shows the apparent viscosity for PED-treated and non-treated sunflower seed mass as a function of the shear rate. Non-Newtonian shear-thinning behavior from the flow curves sunflower seed cake (pretreated and non-treated) exhibit is observed. A similar shear-thinning behavior has also been observed for sesame seed [23] and sage seed solutions [24].

Pulsed electrical discharges contributed to the mechanical destruction of oil globules and the release of free oil to the surface. PED treatment decreases the initial shear stress from 24.5 to 22.9 Pa for samples after treatment with an $E = 16 \text{ kV/cm}$ field and number of discharges $n = 1800$.

Most of the oilseed materials have inhomogeneous loose structure in comparison with cellular structure of fruits and vegetables. PED effect can be visually observed for a first few cell layers on sunflower mass surface. This indicates a filtration or diffusion processes acting inside the internal material structure. As a result, there is no significant difference between viscosity curves for treated by PED and untreated materials (**Figure 4**).

2.3 PED treatment effect on sunflower oil yield during pressing

Initial oil content of heated sunflower meal according to the specification was $49.78 \pm 0.5\%$. To analyze PED treatment effect on oil extraction, heated sunflower

meal was treated and then pressed and extracted using n-hexane. **Figure 5** shows the extraction kinetic curves without and after PED treatment. PED treatment was performed at the following parameters: field strength 13.3 kV/cm, number of pulses 3600, and processing time 2 minutes. **Table 1** shows the oil yield data at various stages of the experiment. With the use of pretreatment with high-voltage discharges, the maximum oil yield was 15.7%, compared to the oil yield without treatment of 13.8% after 3 minutes of pressing (**Table 1**). It is worth noting that the improved oil yield later positively affected the residual oil content in sunflower meal, reducing the amount of oil by 0.58%.

Due to the preliminary destruction of the integrity of the oil cell membranes, the mass has a “sponge-like” structure. Like dielectric breakdown process, the flow of charged particles passes through the structure of the material and forms a channel. Due to the formation of numerous channels, mass transfer characteristics are improved.

Presented curves at **Figure 5** have a similar appearance to the extraction kinetics curve. It can be seen that due to the PED pretreatment, the integrity of the oil cells

Figure 4. Apparent viscosity and shear rate dependence of non-treated seed cake (Δ) and after PED treatment for protocol a with number of discharges $n = 1800$ ($\blacksquare$), $n = 1200$ ($\times$), and $n = 600$ ($\circ$).

Figure 5. The yield of oil versus time dependence during pressing on hydraulic press.

	Pressing		Solvent extraction	
	Without PED	After PED	Without PED	After PED
Oil yeild, %	13.8 ± 0.2	15.7 ± 0.2	34.18 moisture (3.01)	33.47 moisture (1.55)
Residual oil content of sunflower meal, %			1.19 ± 0.06	0.61 ± 0.05

Table 1.
Oil yield values at various stages for treated and untreated heated sunflower meal samples.

disintegrated, which as a result caused an improved oil yield. Previous data related to the application of a pulsed electric field to the oilseed material sunflower showed the possibility of destruction of oilseed cells using electric fields [11]. This is also confirmed by microstructural studies [17].

In sunflower oil production depending on the modernity of production, 0.5–5% of the oil remains in the sunflower oilseed meal [16]. Totally, it reaches up to 25 g/1 kg of sunflower oil as a monetary loss. Preliminary PED treatment could potentially help to extract 99.8% of sunflower oil during extraction. For a large-scale sunflower oil plant with 1200 tons/day capacity, PED technology could potentially increase the sunflower oil production by 6.96 tons per day. This additional revenue increases profit margins and pays back the investment in PED equipment.

2.4 Pulsed electrical discharge treatment effect on oil quality

Chemical parameters such as peroxide and acid value of extracted by pressing sunflower oil are shown in **Table 2**. The peroxide value characterizes the degree of oxidation of fats and oils and expressed in terms of the number of grams of iodine absorbed per gram of the sample. The peroxide value for oil for untreated and PED treated samples were 6.8 and 13.7, respectively. From the authors’ point of view, the double roasting process could cause such high value of the peroxide value after PED treatment. Since to recreate the industrial process of heated sunflower meal processing it was heated for a long time to a temperature of 100°C, first for processing with high-voltage discharges, and as a preparation for pressing. As a result, the active action of oxygen during prolonged heating process contributed to an increase in this parameter by two times.

Acid value (the number of milligrams of potassium hydroxide required to neutralize free acids in 1 g of the sample) was used to check the purity of the oil and characterizes the degree of lipid hydrolysis. The acid number of the processed heated sunflower meal did not change and amounted to 1.43 KON/g.

For a more detailed analysis of the oil quality after treatment, IR spectrometry was used. Data from the obtained spectra for samples without and after processing are shown in **Figure 6**.

The spectrum obtained for pretreated oil had an additional absorption band in the region of 2300–2500 cm⁻¹. Several groups of RNH₃⁺, R₂C=NH⁺, and R_nPH_{3-n} phosphines can fluctuate in this region. Based on these data, it can be assumed that as a result of pulsed electrical discharge treatment, a new substance may be formed, which includes an amino or phospho group, due to the transition of molecules to an excited state. Sunflower seeds contain a whole complex of vitamins and microelements, including phosphorus, which are not present in the sunflower oil. Perhaps a new method of pretreatment allows you to extract nitrogen-containing vitamins such as B₆ and B₉. **Tables 3** and **4** provide a detailed breakdown of the spectrum for amino or phospho groups.

Sample	Peroxide value	Acid value
Untreated	6.8 mmol active O ₂ /kg	1.45 ml KOH/g
PED treated with E = 13.3 kv/cm and number of pulses n = 3600	13.7 mmol active O ₂ /kg	1.43 ml KOH/g

Table 2.
Oil quality indicators for samples treated and untreated by PED.

Figure 6.
IR spectrum of untreated extracted oil (blue line) and after PED treatment (red line).

Salts of amines			
NH_4^+	3300–3030 (3.03–3.30) 1430–1390 (7.00–7.20)	c. c.	ν_{N-H} , wide , δ_{N-H} , wide
RNH_4^+	~3000 (3.33) ~2500 (4.00) ~2000 (5.00) 1600–1575 (6.25–6.35) 1500 (6.67)	δ_{N-H} , wide, c. δ_{N-H} , med. δ_{N-H} , med. δ_{N-H} δ_{N-H}	Few bands
$R_2NH_4^+$	2700–2250 (3.70–4.33)	c.	ν_{N-H} , sometimes it appears as a group of bands
$R_3NH_4^+$	2700–2250 (3.70–4.33)	c.	ν_{N-H} , sometimes it appears as a group of bands
R_4H^+	—	—	Does not have characteristic bands
$R_2C = NH^+$	2500–2300 (4.00–4.34) 2200–1800 (4.55–5.56)	cp	Wide band, sometimes manifested in the form of groups of strips

Table 3.
Decoding the IR spectrum by the amino group.

Thus, according to the results of oil quality parameters, it was shown that PED treatment at the stage of preparation of the material for subsequent processing has a nonsignificant effect. The detected deterioration of the peroxide number value is primarily associated with the setting of the experiment and requires a more detailed analysis.

Phosphines R_nPH_{3-n}	2275–2440 (4.40–4.01) 1080–1090 (9.26–9.17) 910–940 (10.00–10.64) 1405–1440 (7.12–6.94)	ν_{PH} , med. δ_{PH_2} , med. δ_{PH_2} δ_{CH_2P}	
Phosphine oxides $R_3P^+ \rightarrow O^-$	1140–1300 (8.77–7.69) ~1150 (~8.70) ~1190 (~8.40)	c. c. c.	The frequency is affected by the electronegativity of substituents Aliphatic Aromatic
Phosphoric acid $R_n(HO)_{3-n}PO$	2550–2700 (3.92–3.70) 2100–2350 (4.76–4.26)	ν_{OH} , med. ν_{OH} , med.	Wide band

Table 4.
Decoding the IR spectrum for the phospho group.

According to the data obtained, a novel technology for sunflower oil production called pulsed electrical discharge pretreatment has been shown as an emerging technology to improve sunflower oil yield.

3. Pulsed electric field treatment

Pulsed electric field technology is foreseen as a rather flexible tool applicable for a range of cases from stressing of single cells or electroporation of plant cells as a preparation method before extraction or drying [25]. PEF treatment is a series of high-voltage electric pulses of short duration that creates the electric field strength from 1 to 80 kV/cm inside the treatment chamber. In a recent study on oil crops [11], it has been discovered that PEF can damage the structure of oil cells during the process, as well as facilitate the oil extraction without any temperature effects before extraction.

With respect to oil crops, continuous PEF treatment method is a sequence of the following operations: preparing the material (grinding, soaking), PEF treatment in continuous flow mode, drying, and extraction (**Figure 7**).

PEF treatment requires pre-shredding and soaking process of the material to produce a homogeneous, conductive medium. PEF treatment technology has been tested on such oil materials, such as olives [27], canola [28], and rapeseed [13]. As noted above, one of the conditions of PEF treatment is sufficient conductivity of the medium (humidity of material should be not less than 50%) [13]. Conductivity (electrical conductivity) also varies with temperature and dielectric characteristics of the material itself. Most oil-bearing materials are polar dielectrics, which creates certain difficulties for the industrial application of the PEF treatment method. The requirement to conduct the process of wetting of oil-bearing material is not always possible on production and can lead to a negative effect of the treatment [15]. Given the heterogeneity of the structure of the crushed seed, treatment according to the PEF treatment method in the works [13, 15] was conducted in the following sequence: grinding, moisturizing with the addition of water (approximately 1:1), PEF treatment, drying, and screw pressing.

Recent trend of PEF treatment application as a pretreatment prior to extraction of oil from oil-bearing materials. The greatest effect of PEF treatment as a preparatory stage was noted for olives [27]. The authors note that the increase in the yield of olive oil was 13.3 wt.% after processing with pulsed electric field intensity of 2 kV/cm and energy expenditure of 11.25 kJ/kg. The content of

Figure 7.

Pilot PEF system with a continuous-flow chamber for sunflower oil production and continuous-flow treatment chamber with a parameter control system [26].

phenolic components, phytosterols, and tocopherols is significantly higher than in the samples without treatment.

PEF treatment with field strength $E = 7 \text{ kV/cm}$ and energy expenditure $Q = 84 \text{ kJ/kg}$ for rapeseeds allowed to increase the yield of oil by 2%, while the content of various associated useful components in the oil increased [13]. When black cumin seed was exposed to a field strength of $E = 3.25 \text{ kV/cm}$, the yield of oil was increased by 37% [11]. However, the authors do not comment on such a significant increase in output of oil screw press after processing, limited only by the explanation of the effect of the opening of oil cells due to the treatment. [10] noted a 4.9 wt% increase in output of oil of sesame after PEF treatment with a field strength of $E = 20 \text{ kV/cm}$, a pulse frequency of 0.5 Hz, and duration of $10 \mu\text{s}$ with preservation of quality characteristics.

PEF treatment method compared to the process of heating food products is more effective, since it allows to maintain the original quality characteristics of the food product. This treatment can be combined with other electro-physical methods of “green technologies” in the process of extracting vegetable oils [5]. With respect to oleaginous materials, data are available only on a pilot plant with a capacity of 2, 20, and 40 kW.

Based on the above, it can be concluded that PEF technology has a great potential of industrial application by combining the traditional processes of production of vegetable oils during the stages of preparation of the material for extraction and conducting extraction with an overlay of PEF and preparation prior to screw pressing. PEF treatment method regarding oil crops requires a number of preparatory operations such as soaking and subsequent drying, which creates a number of difficulties in the transition to large-scale production. However, this problem can be solved by soaking in solvent, as is done on the example of sunflower seeds [15].

3.1 Sunflower seed surface analysis after PEF treatment

Modification of the surface structure of a sunflower cotyledon after PEF treatment is shown in **Figure 8**. The possibility of sunflower oil cell destruction using short unipolar electrical pulses is clearly noticeable. It was experimentally defined that on the area of 1 mm², more than 25 convex craters appeared. According to average sunflower cell size of 100–200 µm, pulsed electric field was effecting on most of the cell membranes. Such kind of treatment could be used to create a new type of porous body structures [29].

In the case of pulse electric field application, sunflower body can be presented in the form of a modified capillary-porous model with additional microcapillaries. Such new model can be used to describe heat and mass transfer processes in sunflower seeds pretreated by pulsed electric field.

3.2 PEF treatment effect on the oil yield

Extraction yield obtained after PEF treatment is considered to be the main parameter to determine the economic efficiency and global performance of PEF-assisted sunflower oil production. In PEF application for the oil extraction processes from sunflower seeds, the main parameter is the applied energy. Sunflower seed preparation for PEF treatment and further extraction process were performed using ethanol solvent. It was determined that the increase in specific energy for a given electrical conductivity of samples has a monotonical increasing power dependence (**Figure 9**).

However, a further increase in the intensity index E does not significantly increase the oil yield index. The energy consumed (56.7 kJ/kg) for 7 kV/cm is the highest value of the oil yield of 48.5%, which was established experimentally and limited by temperature influence appearing during PEF treatment.

3.3 PEF treatment effect on the oil quality

From a chemical point of view, PEF treatment has no increased reaction of molecular oxygen with triacylglycerine, which negatively effects on chemical characteristics. PEF increases the content of human health-related compounds, such as polyphenols and tocopherols [15]. Sunflower oil spectra and color plot of untreated and PEF-treated sunflower seeds are shown in **Figure 10**.

Figure 8.
Experimental set-up used to generate pulsed electrical discharges in air (a) and schematic visualization of treatment trajectory in a treatment cell (b).

Figure 9.
The oil yield on specific energy of PEF treatment dependence.

Figure 10.
Sunflower oil spectra plot and color plot for PEF-treated (1) marked as a black line and untreated samples (2) marked as a green line.

Non-treated oil obtained after ethanol extraction (**Figure 10**, black line) has a yellowish hue and lies in the second quadrant of the color spectrum. The same results of the oil yield were obtained for PEF-treated sunflower mass by ethanol (green line). Main color parameters such as L^* , a^* , and b^* for extracted sunflower oil are listed in **Table 5**. PEF treatment affected lightness on sunflower oil, ranging from 91.68 in untreated to 92.06 in PEF-treated samples. Applying of PEF treatment allowed to increase the blue-yellow coordinate b^* from -1.84 up to -1.46 . For PEF pretreated sunflower mass, initial value of green-red coordinate, a^* , decreased from 9.51 down to 7.06. From the authors' point of view, such difference in color parameters might be due to a chemical reaction of electrodes and plant material.

In summary, the initial sunflower oil after PEF treatment became more yellowish and greenish oil.

According to the data obtained in this chapter, a novel technology for sunflower oil production called pulsed electric field pretreatment has been shown as an emerging technology to improve sunflower oil yield up to 8.05% using ethanol as a solvent. This is not a maximum possible increase, since the disintegration index did not reach its maximal value for a completely destroyed amount of cell membranes. However, in production cycles, factories are using n-hexane which is more efficient for extraction processes. PEF treatment in a continuous flow of roasted sunflower seed cake material could help sunflower oil mills to increase profit margins.

Sample	L*	a*	b*
Untreated	91.68	-1.84	9.51
PEF-treated	92.06	-1.46	7.06

Table 5.
General color parameters of control and PEF sunflower oil.

4. Conclusions

Pulsed electrical discharge and pulsed electric field treatment were studied on physical, morphological, and oil recovery characteristics of sunflower seeds. The efficiency of PED technology for sunflower seed oil yield and oil quality, along with surface and rheological behavior, was studied. Solvent extraction efficiency and internal structure changes along with oil quality were studied for sunflower seeds pretreated by PEF. Our study demonstrates significance of both technologies for structural change and technological parameter efficiency.

The obtained effects are directly dependent on the processing method, preliminary preparation of the material, its initial component composition, and structure of the material. Moreover, as shown by literature data, the use of these electrical treatment methods allows to obtain products (oils), enriched with bioactive components. From the point of view of product quality, the proposed methods are able to preserve the original taste and organoleptic and qualitative indicators of oil-bearing materials and can be used to obtain high-quality functional products. Most of the research related to the study of methods of PED and PEF treatment should be carried out on pilot equipment, with technological parameters close to the industrial scale. It undoubtedly actualizes the obtained results and allows to predict the effects for the industrial scale.

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Conflict of interest

The authors declare no conflict of interest.

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