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Identification of Essential Oil Components from Rose Flower with High Pulsed Electric Field (HPEF) Treatment using Water Distillation Method

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***Abstract*—*Rosa damascena* Mill, frequently known as "damask rose" is a part of Rosaceae with an aroma in great demand by the public. Therefore, various derivative products utilize aromatic compounds from rose petals obtained through extraction, including essential oil. However, the effectiveness of extraction using the hydrodistillation method is still low. To address this issue, the modification of extraction process by combining HPEF as an initial pretreatment followed by hydrodistillation to enhance the quality and yield of rose essential oil was needed. The materials used were 5 kg of rose flowers and 40 liters of water as solvent. The method used was giving HPEF to the rose petals with an electric field of 7.5 kV/cm for 13 seconds and varying the frequency of HPEF (10 Hz, 20 Hz, 30 Hz). Furthermore, the rose petals that had passed the initial pretreatment went through the hydrodistillation stage by adding solvent. The distillate containing rose essential oil and solvent was separated based on the difference in density. The essential oil produced was quantified and analyzed for its compound using GC-MS. The results showed that HPEF treatment with a frequency of 20 Hz produced the highest essential oil yield (0.033%) and successfully extracted essential oils containing complex compounds such as 2-Hexyl-1-decanol and 1-nonadecene. The yield of essential oil produced still cannot be optimal, but there is an improvement compared to hydrodistillation without HPEF so further research can be carried out regarding the use of HPEF in the extraction process.**

***Keywords*—Compound; HPEF; hydrodistillation; rose essential oil.**

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I. INTRODUCTION

High Pulsed Electric Field (HPEF) is a non-thermal method that is extensively used in food and agriculture to improve product quality [1]. The application of HPEF to samples is through the provision of high voltage electric pulses in a brief time where the sample or material being tested is placed between two electrodes [2]. The principle used in HPEF is the electroporation mechanism, which is the process of increasing permeability of the cell membrane as a result of HPEF treatment, causing the components contained in the cell to escape into the media more easily [3]. The electroporation phenomenon makes the mass transfer process more efficient. Thus, HPEF is often used as a preliminary treatment in the food industry before products or ingredients are preserved through freezing, heating, or drying [4]. This phenomenon is one of the factors that causes HPEF to be a method that is quite attractive today in food processing because it can retain nutrition, taste, color, and texture of food [5]. In addition, HPEF can also increase efficiency in the process of extracting bioactive components from natural materials [6].

Rosa damascena Mill, frequently recognized as "damask rose" is a part of Rosaceae with an aroma in great demand by the public [7]. Therefore, various derivative products utilize aromatic compounds from rose petals obtained through extraction, including essential oil, rose water [8], rose concentrate, and rose absolute [9]. These products are mostly found in the pharmaceutical, food, and cosmetic fields [10]. The bioactive contents in rose petals include flavonoids (kaempferol and quercetin derivatives), anthocyanins (cyanidin and pelargonidin derivatives), and volatile terpenoids (β-citronellol, geraniol, and nerol) [11]. These compounds have various functional properties, including antioxidants, as well as antibacterial and antiviral properties [7]. Therefore, various kinds of research are being conducted related to the extraction process of bioactive components from rose petals. [12] conducted research on the extraction of damask rose essential oil (*Rosa damascena* Mill.) using the

hydrodistillation method. The results indicated the yield of essential oil gained from rose flowers in the first vegetation year was only 0.044%. [13] also used hydrodistillation method to obtain essential oil from rose geranium (*Pelargonium hybrid*). The yield of rose essential oil was 0.12% (w/w). [11] also extracted rose essential oil using the same method and the yield of essential oil was in the range of 0.010 to 0.055% (v/w).

Hydrodistillation is one of the conventional methods commonly used in the essential oil extraction process, although currently, various methods have begun to emerge that are claimed to be better than the hydrodistillation method [14]. The emerging methods involve supercritical fluid extraction (SFE) [15], ultrasonic-assisted extraction (UAE) [16], and microwave-assisted extraction (MAE) [17]. However, these methods have several disadvantages, including being difficult to apply at the industrial level due to the high charge of equipment, operation, and maintenance [18]. Therefore, the hydrodistillation method remains the best choice even though it has disadvantages such as extensive distillation period, high solvent waste, poor essential oil yield and extraction rate, pollution from organic solvents, and heat-sensitive component destruction [19]. Hence, modifications are needed in the hydrodistillation process, one of which is conducting pretreatment using HPEF to raise the performance of the distillation system. According to research by [20], yields of essential oils extracted from eucalyptus and rosemary leaf were found to be 17% and 11% higher, respectively, when HPEF was used as a pretreatment before the extraction process. This was achieved with an electric field of 2 kV/cm and a specific energy of roughly 10 kJ/kg, followed by an extraction process lasting 30 and 60 minutes. HPEF-treated dried thyme leaves at an electric field of 1 kV/cm with 0.4 kJ/kg and 30 min hydrodistillation time could increase the extraction yield up to 40% compared to the current method. [2] conducted research on the effect of HPEF treatment on beard leaf essential oil (*Mentha spicata* L.) and obtained a maximum yield of 0.94% with a distillation time of 120 minutes. Analysis using gas chromatography/mass spectrometry (GC/MS) faced that HPEF treatment did not affect essential oil quality. In addition, HPEF pretreatment led to significantly shorter distillation time and physicochemical analysis of HPEF-treated essential oil showed better stability.

In the current study, an initial HPEF pretreatment was conducted before the hydrodistillation process to increase the quantity and quality of essential oil from rose flowers (*Rosa damascena* Mill). This study used GC-MS testing to assess the essential oil yield from rose flowers treated with HPEF as well as the bioactive components present.

II. Materials and Method

A. Materials

Roses (*Rosa damascena* Mill) were obtained from 50 hectares of smallholder rose gardens in Karangpring Village, Panti Subdistrict, Jember Regency S 8º05 – 8º08 and E 113º38 – 113º45 (Fiq 1).

Fig. 1 Location of roses

B. HPEF Treatments

HPEF device was designed in the laboratory with power supply components from 15 kV AC transformers, capacitors, resistors, circuit breakers, and treatment chambers (Fig 2).

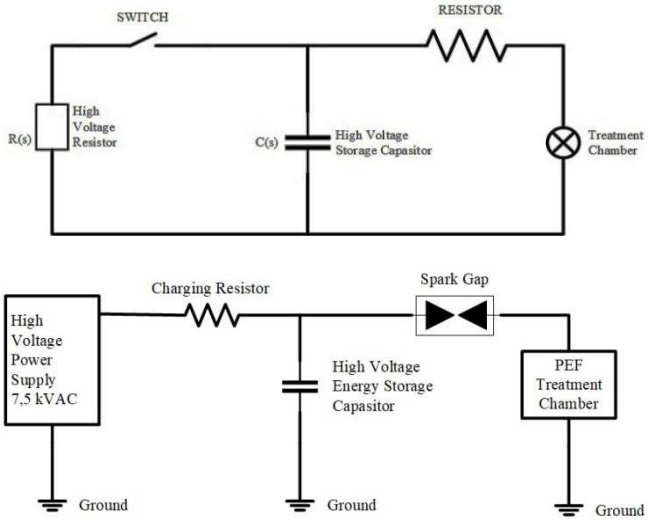

Fig. 2 HPEF treatment system

5 kg of roses were placed in the treatment chamber at a distance of 2 cm to obtain a field strength (E) of 7.5 kV/cm. [21] conducted HPEF-assisted extraction to obtain crude aqueous extracts from the brown alga *Laminaria digitata* with an electric field treatment of 7.5 kV/cm. This HPEF system resulted in a yield of 15% and a supernatant yield was 70% due to cell electroporation. The field strength can be formulated as equation (1):

$$E = \frac{U}{d} \quad (1)$$

where: U is voltage (V) and d is electrode distance (cm). The roses received a 13-second HPEF treatment using exponential pulses and a field strength of 7.5 kV/cm. Several frequencies were used for the treatment (10 Hz, 20 Hz, and 30 Hz).

C. Hydrodistilation

Extraction of rose flower essential oil was done with a distillation device (Fig 3).

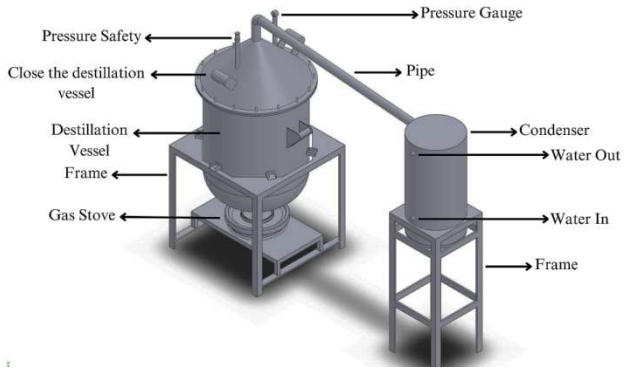

Fig. 3 A set of distillation equipment for hydro distillation

The HPEF-treated rose samples were placed into a distillation chamber and 40 liters of water was used as solvent. The distillation process was carried out for 6 hours to obtain rose essential oil. The essential oil was separated with solvent based on the difference in density and kept at 4°C in a dark place before GC/MS analysis.

D. Compound Analysis

A Shimadzu capillary gas chromatograph type GP-2010 Plus, which included the Shimadzu GC-2010 Plus Capillary GC, Shimadzu GCMS-QP2010 Plus, TD-20 Thermal Desorption Analyzer, Shimadzu AOC-20s Auto Sampler, and Shimadzu AOC-20i Auto-Injector, was used to perform the GC/MS (Gas Chromatography-Mass Spectrometry) analysis.

TABLE I
SPECIFICATIONS OF GC-MS TYPE GP-2010

Type	Specification
Mass range (m/z)	1.5 to 1000
Ionization mode	EI
EI scan sensitivity (m/z)	1 pg octafluoronaphthalene 272 S/N > 200
Column flow	Up to 4mL/min
Pump	Turbomolecular pump (58 L/sec for He) Rotary pump 30 L/min (60Hz)

TABLE II
SHIMADZU TD-20 THERMAL DESORPTION ANALYZER SPECIFICATIONS

Type	Specification
Sample tube	Outer diameter: Approx. 6.35 mm (1/4 inches); Length: 90 mm
Heating temperature range	80°C to 400°C (unit: 1°C)
Flow-rate control range	21 to 150 mL/min (unit: 1 mL/min)
Sampling line temperature	80°C to 350°C (unit: 1°C)
Tube handling	Capping/decapping mechanism based on stepping motor

According to its requirements, the Shimadzu AOC-20s/i Auto Sampler/Auto-Injector can process up to 150 samples. When used on its own, the AOC-20i can handle up to 12 samples.

III. RESULTS AND DISCUSSION

A. Treatment Chamber

According to [22], polysulfone and stainless steel are the preferred materials for insulation and electrodes. Parallel plate-type treatment chamber is considered good enough to be used at short electrode spacing with uniform field strength [23]. According to [24], the power required for the pretreatment process is related to HPEF and the electric field strength value. The electric power can be formulated as equation (2):

$$P = \frac{f\,C_o V^2}{2} = \frac{f\,\tau\,V}{2\,R} \qquad (2)$$

where P = Electrical power for HPEF process (W); f = Frequency (Hz); Co = Energy stored in capacitor (μF); V = Maximum voltage - Vmax (kV); τ = Pulse width (μs); R = resistance (Ω).

Based on the equation (2), the greater the frequency, the higher the power required. This leads to greater field strength. Following [25], cell wall destabilization establishes with indications of enlarged permeability in the cell wall, progresses to swelling in the cell wall, and ends with the breakdown of the cell membrane (Fig. 4). The greater the electric field, the greater the potential for electroporation in cells due to an increase in membrane permeability [3].

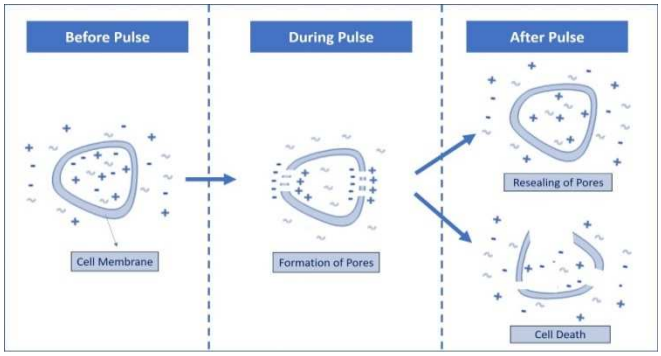

Fig. 4 Electroporation cell membrane

The dimensions of parallel plate type treatment chamber were 40 cm wide, 60 cm long, and 30 cm high. The electrode spacing could be adjusted between 1 and 30 cm (Fig 5a and Fig 5b) [26].

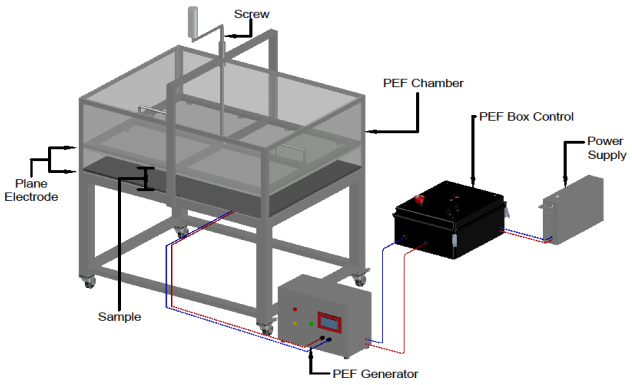

Fig. 5a A set of PEF generator equipment (treatment chamber)

Based on Fig 5a, the specifications of HPEF design are (1) Screw for electrode spacing, (2) treatment chamber box cover, (3) Parallel plate type treatment chamber, (4) Frame, (5) HPEF Box Control, (6) HPEF Generator, (7) HPEF Control, (8) Power supply. The electrical panel is attached discretely outside the HPEF box. The electrical panel consists of microcontroller parts, dimmer, SSR, pilot light, and 1-phase 10A MCB. The pilot light is an indicator of the voltage input

to the transformer with an input voltage of 220 VAC with a current of 6 A.

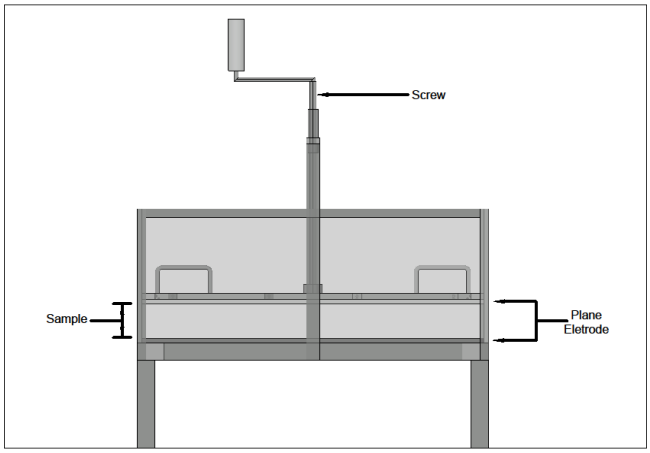

Fig. 5b Altitude settings treatment chamber

The wiring diagram of the HPEF electronic devices is shown in Figure 6. When in operation, the HPEF voltage generator uses a 15kV neon sign transformer connected to a 450 VAC dimmer and SSR. The dimmer customizes the input pulse to the transformer from the state power company.

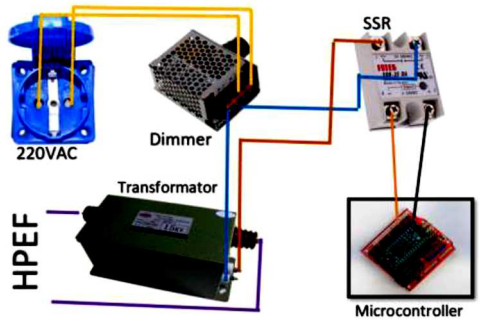

Fig. 6 Wiring Diagram System

B. *HPEF Testing*

The testing of the HPEF device was carried out in the chamber without any sample first. It aimed to determine the presence of electric shock among the anode and cathode plates. Electric shock appeared at high voltage power >1kV as seen in Fig 7. After the electric shock was confirmed to appear, testing using samples was carried out as shown in Fig 8. The length between the electrodes was set at 2 cm.

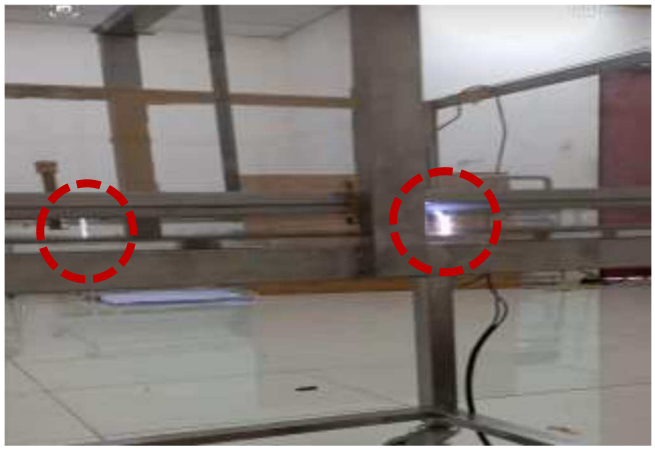

Fig. 7 HPEF testing without sample

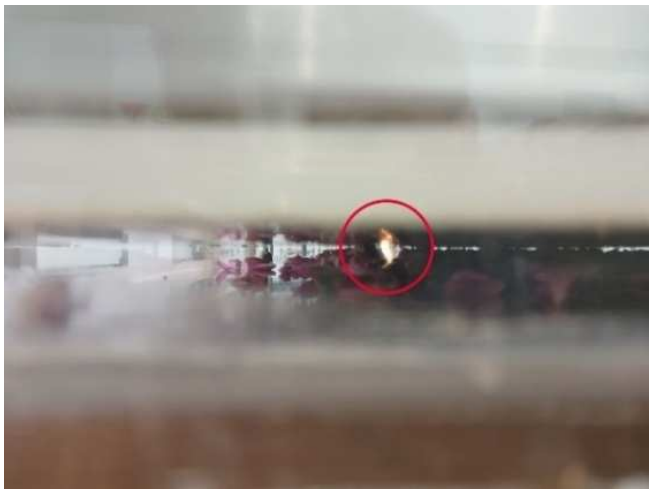

Fig. 8 HPEF testing non-liquid materials

C. *Yield of Essential Oil treated under HPEF*

The extraction method of rose flower essential oil in the control and HPEF treatments goes through the same steps. The only difference part lies in the initial pretreatment in the form of exposure to HPEF on the sample. Thus, the data presented fully represents the effect of HPEF exposure.

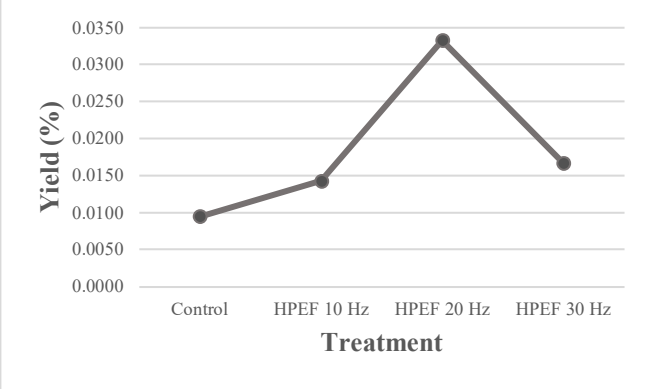

Fig. 9 Effect of frequency on yield of rose essential oil

The efficiency of the essential oil extraction process increased with increasing frequency from 10 Hz to 30 Hz. There was also an increase in essential oil yield when compared to the sample without PEF. At a frequency of 20 Hz, the essential oil yield reached an optimum condition and then at 30 Hz there was a decrease in essential oil yield (Fig 9). The highest yield obtained at 20 Hz was 0.033%. This is influenced by the process of cell electroporation that occurs increasingly along with the greater frequency given. This phenomenon can be described by the potential distiction between the inner and outer cell membrane that is getting bigger in the presence of electrostatic forces, resulting in damage to the cell structure followed by the process of volatilization of essential oil ingredients [27]. However, when the frequency is excessive, it causes damage to the cells resulting in the loss of bioactive components in essential oils during the HPEF process before the extraction. The study conducted by [28] pointed out that the excessive use of electric field and number of pulses caused degradation of the cell wall, thus reducing the extraction performance of essential oil and the functional properties of the essential oil produced. Meanwhile, research conducted by [13] using hydrodistillation without preliminary treatment showed

better results. But in addition to the provision of preliminary treatment, the extraction efficiency of essential oil can also be influenced by the geographical conditions where the roses grow [29].

D. Identification of Rose Flower Essential Oil Components

The leading components of rose essential oil are phenyl ethyl alcohol, geraniol, linalool, benzaldehyde, citronellyl acetate, benzyl alcohol, geranyl acetate, citronellol, nerol, stearopten, farnesol, geranic, eugenol, and myrcene [30], [31]. The essential oil components of samples without HPEF pretreatment were compared with the 10 Hz, 20 Hz, and 30 Hz treatments based on GC-MS testing to determine the profile (type and number of components) of the chemical constituents of essential oil.

1) Essential Oil Composition of Control Treatment:

The major components of rose essential oil with 30 Hz HPEF treatment are listed in Table 3.

TABLE III
ESSENTIAL OIL COMPOSITION OF CONTROL TREATMENT

Peak	R Time	Area (%)	Name
1	1.936	35.30	Butylcyclobutane
2	4.769	0.83	Benzen, 1,2 Dymethyl
3	5.832	1.02	Etanol 2 Buthoxy
4	7.998	2.01	Beta Terpynil acetat
5	9.119	0.33	Benzene-1-ethyl-3-methyl-CAS
6	10.566	0.34	Benzene, 1 methyl-3-(1-methyletyl)-(CAS)
7	11.317	0.95	1-Dodecene (CAS)
8	14.277	10.67	Benzenethanol (CAS)
9	15.165	6.69	Beta-Citronellol
10	16.193	2.39	Geraniol
11	16.926	4.48	Octadecane, 1-chloro-(CAS)
12	18.422	0.86	Chyclohexanol,2-(1-1dimethylethyl)-(CAS)
13	19.574	0.49	Octadecane, 1-Chloro-(CAS)
14	21.470	2.31	Germacrene D
15	22.276	2.73	1-Nanodecene (CAS)
16	24.008	2.61	Phenol, 2-4-bis (1,1-dimethyl ethyl)- (CAS)
17	24.582	0.98	Nanodecane
18	27.025	5.63	1-Nanodecene (CAS)
19	29.284	8.06	Hexadecane (CAS)
20	30.440	1.11	Ethyl linoleate
21	31.345	3.17	Pentatriacontane (CAS)
22	33.487	6.19	Eicosane (CAS)
23	34.099	0.83	2-Hexyldecanoic acid
		100.00	

Referring to the chromatogram in Figure 10, it can be observed that the distillation process without HPEF can produce 3 main components in rose essential oil, namely benzenethanol, β-citronellol, and geraniol with no optimal levels. Benzenethanol known as 2-phenylethyl alcohol and eicosane are compounds that produce the distinctive aroma of roses [32].

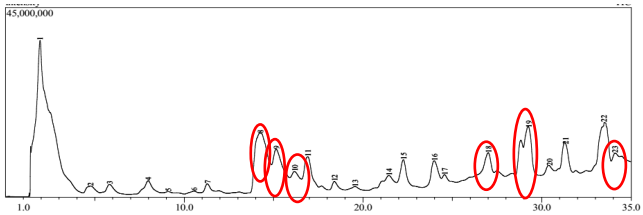

Fig. 10 Chromatogram of rose essential oil without treatment

In addition, β-citronellol and geraniol, which are included in the terpene alcohol group, are also major compounds in rose flowers that produce a distinctive floral aroma. Geraniol itself gives a sweet and fresh aroma to rose essential oil [31]. This finding was following previous work conducted by [33], the essential oil produced from the water distillation process had a high content of β-citronellol and geraniol which acted as antimicrobials. Other components contained in the extracted rose essential oil are nonadecane, and nanodecene which are included in stearoptenes [31]. These compounds will affect the solidification of rose flower essential oil at ambient and lower temperatures.

2) Essential Oil Composition of 10 Hz Treatment:

The primary components of rose essential oil with 10 Hz HPEF treatment are listed in Table 4.

TABLE IV
ESSENTIAL OIL COMPOSITION OF HPEF 10 HZ TREATMENT

Peak	R Time	Area (%)	Name
1	0.213	0.06	Hi-oleic safflower oil (CAS)
2	1.483	0.63	Carbon dioxide (CAS)
3	1.682	0.78	n-Hexylmethylamine
4	4.036	8.25	Acetic acid (CAS)
5	4.279	3.82	2-Propanone, 1-hydroxy-(CAS)
6	4.858	1.51	2,2-Bioxirane
7	5.805	1.80	2-Furancarboxaldehyde (CAS)
8	6.732	1.74	2-Furamethanol (CAS)
9	8.620	0.65	2,3-Dyhydro-3,5-dyhydro-6-methyl
10	9.131	1.51	2 (1H-Pyrimidinone, 1-methyl
11	14.085	27.34	Benzeneethanol (CAS)
12	16.048	11.15	2,3-Dyhydro-3,5-dyhydro-6-methyl
13	16.941	1.56	1-Octanol, 2-Buthy-(CAS)
14	18.642	1.24	Benzoic acid
15	2.066	11.61	2-Furancarboxaldehyde
16	22.221	2.55	2-Ethyl-1-dodecanol
17	23.849	0.50	Cyclobutaneecarboxylic acid
18	24.713	3.05	1-Nonadecene (CAS)
19	25.564	1.15	6-Tridecanol, 3,9-diethyl (CAS)
20	26.999	1.91	2-Hexyl-1-decanol
21	29.161	6.65	Tetratetracontane (CAS)
22	30.443	0.80	Isolongifolol
23	31.311	2.22	Pentatriacontane (CAS)
24	33.303	6.58	Pentacosane
25	34.245	0.93	Phthalic, didecyl ester
		100.00	

As shown in Table 4 and Figure 11, it can be described that the essential oil produced contains Benzenethanol with a larger area compared to the control treatment. However, HPEF using 10 Hz treatment did not create β-citronellol and geraniol. This treatment obtained compound that is rarely found in rose flower essential oil, namely Pentacosane. Pentacosane is found in apple leaves (Malus domestica) and Pedicularis condensate [34]. This can be influenced by various factors, including geographical distribution and seasonal variation, contributing to varying rose essential oil composition. [29].

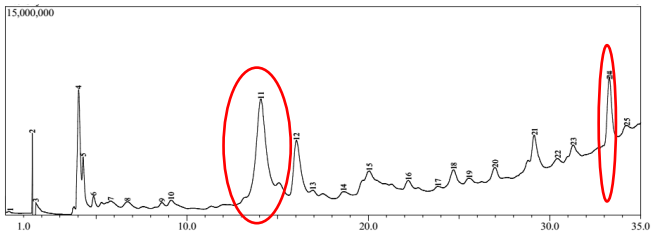

Fig. 11 Chromatogram of rose essential oil treated at 10 Hz

3) Essential Oil Composition of 20 Hz Treatment

The main components of rose essential oil with 20 Hz HPEF treatment are listed in Table 5.

TABLE V
ESSENTIAL OIL COMPOSITION OF HPEF 20 HZ TREATMENT

Peak	R Time	Area (%)	Name
1	0.206	0.09	Hi-oleic safflower oil (CAS)
2	1.559	0.22	Methane, tetranitro (CAS)
3	1.807	0.74	Carbamic acid, monoammo-nium salt (CAS)
4	3.910	8.35	Acetic acid (CAS)
5	4.176	4.19	2-Propanone, 1-hydroxy- (CAS)
6	5.050	0.67	1-Penten-3-one (CAS)
7	5.917	0.63	3-Furaldehyde
8	6.976	1.25	2-Furanmethanol
9	7.656	0.34	2-cyclopeptene-1,4-dione
10	8.854	0.84	Ethyl undec-2-enoate
11	11.358	0.54	Hexadecane, 1-chloro- (CAS)
12	14.148	30.35	Benzenethanol (CAS)
13	16.109	9.02	2,3-Dehydro-3,5-Dehydro-6-methyl
14	17.009	4.09	1-Octanol, 2 butyl- (CAS)
15	18.656	3.04	1-Benzamide-piperedine
16	19.705	13.02	1-Nonadecene (CAS)
17	21.327	1.59	1,1-Biphenyl (CAS)
18	22.255	4.77	2-Hexyl-1-decanol
19	23.846	0.95	Cyclobutanecarboxylic aid
20	24.742	4.71	Cyclotetracosane
21	25.573	1.58	6-Tridecanol,3,9-Diethyl (CAS)
22	27.038	1.55	2-Hexyl-1-decanol
23	29.282	2.73	1-Pentacontanol (CAS)
24	31.391	1.30	1-Hexadecanesulfonyl chloride
25	33.406	1.56	Tetrapentacontane, 1,54-dibromo
26	34.235	1.88	1,2-Benzenedicarboxyllic acid, diisodecyl ester
		100.00	

Based on Table 5 and Figure 12, the HPEF using 20 Hz frequency gives the more diverse distribution compounds contained in rose flower essential oil. Benzenethanol has the largest area of chromatogram that affects the aroma of rose flower essential oil produced. Acetic acid is also obtained in the extraction process with this frequency.

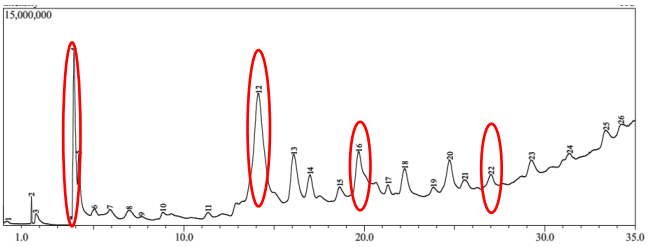

Fig. 12 Chromatogram of rose essential oil treated at 20 Hz

This shows that HPEF can extract difficult and rare compounds that exist in the sample [25]. 2-Hexyl-1-decanol is also a rarely compound found in rose essential oil and commonly in chrysanthemum flowers. 2-Hexyl-1-decanol is a long-chain alcohol fatty acid compound that can be used as an opacifier, emulsifier, and agent that can thicken solutions and stabilize the formation of soap foam [35]. In the 20 Hz HPEF treatment, 1-nonadecene also has a large enough area and becomes the most valuable bioactive exist in the rose essential oils [36].

4) Essential Oil Composition of 30 Hz Treatment:

The primary components of rose essential oil with 30 Hz HPEF treatment are listed in Table 6.

TABLE VI
ESSENTIAL OIL COMPOSITION OF HPEF 30 HZ TREATMENT

Peak	R Time	Area (%)	Name
1	0.054	0.04	Pentatricontane (CAS)
2	1.495	0.24	Propiolic acid
3	1.695	0.71	n-Hexylmethylamine
4	4.475	0.41	Propananl, 2-oxo (CAS)
5	4.728	5.03	Acetic acid (CAS)
6	4.961	2.73	2-Propanone,1-hydroxy-(CAS)
7	5.518	4.83	2-Propenoic acid, 2propenyl ester (CAS)
8	6.999	1.86	2-Furanmethanol (CAS)
9	7.733	0.98	2-cyclopentene-1,4-dione
10	8.761	1.22	Ethyl Undec,2 enoate
11	9.189	2.29	2-Furancarboxyldehyde, 5-methyl (CAS)
12	10.496	0.33	Hyrazine, 1-1-demethyl- (CAS)
13	12.057	0.86	(2S)-methyl 5-ethoxy-3, 4-dihydro-2H-pyrrol
14	14.193	14.02	Benzenethanol (CAS)
15	15.255	1.60	Citronelly acetat
16	16.338	8.78	2,3-Dehydro-3,5-dehydroxy - 6-methyl-4H-pyrrol
17	17.150	0.66	9-Eucosine
18	17.589	0.39	2-Acetyl-2-hydroxy-gamma-butirolactone
19	18.576	0.75	Benzoic acid
20	20.241	10.58	2-Furrancarboxyldehide
21	21.611	0.98	Germacrene-D
22	22.450	1.89	1-Nodecene (CAS)
23	24.099	1.48	Phenol, 2-4 bis (1,1-dymethyl (CAS)
24	24.836	0.96	Nonadecene (CAS)
25	25.779	0.46	Octadecanoic acid (CAS)
26	27.221	4.84	Decanedioic acid, didecly ester
27	29.399	7.14	Hexadecane (CAS)
28	30.558	0.84	Isolongifolol
29	31.522	2.87	Tetracontane
30	32.965	9.31	Eicosane (CAS)
31	33.634	7.14	Hexadecane (CAS)
32	34.198	3.76	2-Hexyldeconoic acid
		100.00	

Based on Table 6 and Figure 13, the HPEF of 30 Hz shows that benzenethanol and eicosane compounds are still present in the rose essential oil produced as compounds that favor the distinctive aroma of rose essential oil. This treatment also obtained compounds that enhance the physical characteristics of essential oils, namely nonadecene and hexadecene. In addition, there is a germacrene compound which is a sesquiterpene group and is found in roses that have fully bloomed [37]. Germacrene is also a group of minor compounds found in rose essential oil. HPEF 30 Hz treatment is proven to be able to extract these compounds which also play a role as a producer of rose flower aroma [30].

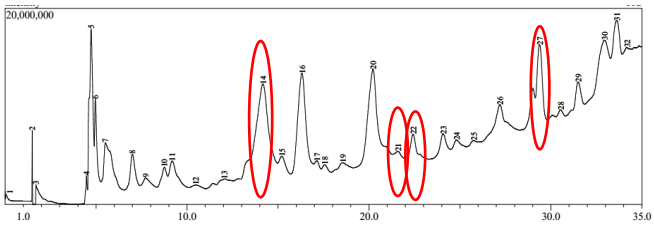

Fig. 13 Chromatogram of rose essential oil treated at 30 Hz

The results of active component analysis between the control, 10 Hz HPEF treatment, 20 Hz HPEF treatment, and 30 Hz HPEF treatment were 23, 25, 26, and 32 components, respectively, with GC-MS results listed in Table 7.

TABLE VII
COMPARISON OF ROSE ESSENTIAL OIL COMPOSITION WITH VARIOUS TREATMENTS

No	Compound (%)	Control	HPEF 10 Hz	HPEF 20 Hz	HPEF 30 Hz
1	Pentatricontane (CAS)				√
2	Hi-oleic safflower oil (CAS)		√	√	
3	Methane, tetranitro (CAS)			√	
4	Carbamic acid, mono-ammo-nium salt (CAS)			√	
5	Propiolic acid				√
6	n-Hexylmethylamine		√		√
7	Butylcyclobutane	√			
8	Acetic acid (CAS)		√	√	√
9	Carbon dioxide (CAS)		√		
10	Propananl, 2-oxo (CAS)				√
11	2-Propanone, 1-hydroxy- (CAS)		√	√	√
12	Benzen, 1,2 Dymethyl	√			
13	2,2-Bioxirane		√		
14	1-Penten-3-one (CAS)			√	
15	3-Furaldehyde			√	
16	2-Furanmethanol (CAS)			√	
17	Etanol 2 Buthoxy	√			
18	2-Furancarboxaldehyde (CAS)		√		
19	2-Furamethanol (CAS)		√		
20	2-Propenoic acid, 2propenyl ester (CAS)				√
21	Beta Terpynil acetat	√			
22	2,3-Dyhydro-3,5-dyhydro-6-methyl		√		
23	2-Furanmethanol				√
24	2-cyclopeptene-1,4-dione			√	√
25	Ethyl undec-2-enoate			√	√
26	Benzene-1-ethyl-3-methyl-CAS	√			
27	2 (1H-Pyrimidinone, 1-methyl		√		
28	2-Furancarboxyldehyde, 5-methyl (CAS)				√
29	Hyrazine, 1-1-demethyl- (CAS)				√
30	Benzene, 1 methyl-3-(1-methyletyl)-(CAS)	√			
31	1-Dodecene (CAS)	√			
32	Hexadecane, 1-chloro- (CAS)			√	
33	(2S)-methyl 5-ethoxy-3, 4-dihydro-2H-pyrrol				√
34	Benzenethanol (CAS)	√	√	√	√
35	2,3-Dehydro-3,5-Dehydro-6-methyl			√	
36	Beta-Citronellol	√			
37	Citronelly acetat				√
38	Geraniol	√			
39	2,3-Dehydro-3,5-dehydroxy - 6-methyl-4H-pyrrol				√
40	1-Octanol, 2-Buthy-(CAS)		√	√	
41	Octadecane, 1-chloro-(CAS)	√			
42	9-Eucosine				√
43	2-Acetyl-2-hydroxy-gamma-butirolactone				√
44	Chyclohexanol,2-(1-1dimethylethyl)-(CAS)	√			
45	1-Benzamide-piperedine			√	
46	Benzoic acid		√		√
47	Octadecane, 1-Chloro-(CAS)	√			
48	Germacrene D	√			√
49	1,1-Biphenyl (CAS)			√	
50	1-Nonadecene (CAS)		√	√	√
51	1-Nanodecene (CAS)	√			
52	2-Ethyl-1-dodecanol		√		
53	Cyclobutaneecarboxylic acid		√		
54	2-Furrancarboxyldehide				√
55	2-Hexyl-1-decanol		√	√	
56	Phenol, 2-4-bis (1,1-dimethyl ethyl)- (CAS)	√			√
57	Nanodecane	√			
58	Nonadecene (CAS)				√
59	6-Tridecanol, 3,9-diethyl (CAS)		√		
60	Hexadecane (CAS)	√			√

No	Compound (%)	Control	HPEF 10 Hz	HPEF 20 Hz	HPEF 30 Hz
61	Tetratetracontane (CAS)		√		
62	Ethyl linoleate	√			
63	Pentatriacontane (CAS)	√	√		
64	Eicosane (CAS)	√			√
65	Pentacosane		√		
66	2-Hexyldecanoic acid	√			
67	Phthalic, didecyl ester		√		
68	Cyclobutanecarboxylic aid			√	
69	Cyclotetracosane			√	
70	6-Tridecanol,3,9-Diethyl (CAS)			√	
71	Octadecanoic acid (CAS)				√
72	Decanedioic acid, didecly ester				√
73	1-Pentacontanol (CAS)			√	
74	Isolongifolol		√		√
75	1-Hexadecanesulfonyl chloride			√	
76	Tetracontane				√
77	Tetrapentacontane, 1,54-dibromo			√	
78	1,2-Benzenedicarboxy-llic acid, diisodecyl ester			√	
79	2-Hexyldeconoic acid				√

Based on the GC-MS analysis, it appeared that essential oil from rose flowers contains hydrocarbon groups both aliphatic and alicyclic with saturated and unsaturated bonds. The compound that was consistently obtained in the distillation process with various treatments both control and PEF was Benzenethanol (CAS) or phenyl ethyl alcohol. It is a marker in rose essential oil that produces a distinctive aroma of rose flowers in the essential oil produced [38]. One of the largest hydrocarbon compounds in rose essential oil that plays a role in determining the physical characteristics of essential oils is the stearoptenes group, including 1-nonadecene, nanodecene, and octadecene. The type of compound and concentration of stearoptenes compounds will affect the solidification process of essential oils. According to Table 7, it can be observed that control treatment has more types of stearoptenes than the HPEF treatment. This can affect the solidification process of essential oils at room temperature or lower temperatures [39]

IV. Conclusion

This study revealed that the extraction of rose essential oil using PEF treatment followed by hydrodistillation was able to enhance the yield of essential oil produced by 0.033% at a frequency of 20 Hz and an electrical field of 7.5 kV/cm with a distillation time of 6 hours. According to the results of GC-MS analysis, PEF treatment could help to extract compounds that are difficult to obtain in rose flowers such as 2-Hexyl-1-decanol and 1-nonadecene which are compounds that contribute to the aroma of rose flowers. Therefore, initial pretreatment using PEF in the hydrodistillation process can effectively boost the quality and yield of rose essential oil.

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