Review: Marsh rosemary (*Rhododendron tomentosum* Harmaja (ex *Ledum palustre* Linn) growing in Lithuania) essential oils and their properties

Asta Judžentienė*

Department of Organic Chemistry, Center for Physical Sciences and Technology, 3 Saulėtekio Avenue, 10257 Vilnius, Lithuania

The paper reviews already (in the past fifteen years) published data from research articles on essential oils (EOs) and their biological properties (such as antioxidant, antifungal, anti-inflammatory and toxic activity) of marsh rosemary (*Rhododendron tomentosum* (Stokes) Harmaja (ex *Ledum palustre* Linnaeus, Ericaceae Juss.) growing wild in Lithuania. *Rh. tomentosum* is a perennial woody shrub (up to 1 m in height) with evergreen leaves and small white or white-pink sticky flowers grouped in racemes. The plant emits a strong specific smell that affects the central nervous system, and may cause nausea, headache or aggressive behaviour to some people. Only one species of the plant (ex *L. palustre var. palustre*) grows in Lithuania, mainly forming colonies in limited areas over all the territory.

Marsh rosemary are widely used in folk medicine and homeopathy for treatment of various sickness, externally and internally as well. Most applications of *Rh. tomentosum* and pharmacological properties have been validated by scientific researches. In Lithuania, the plant is used for healing rheumatism, different pains, insect bites, eczema and other skin problems, infections, bronchitis, asthma, cold, tuberculosis, to block bleeding, etc.

*Rhododendron tomentosum* H. (ex *Ledum palustre* L.) plants, the essential oils (EOs) of which are already investigated, were collected mostly in the Eastern part of the country (Rokiškis, Utena, Vilnius and Šalčininkai districts). Monoterpane hydrocarbons, p-cymene, myrcene and limonene, bicyclic monoterpenoid ascaridole and oxygenated sesquiterpenes, ledol, palustrol and cyclocolorenone isomers, were found to be principal compounds in the investigated EOs. Some oils contained appreciable quantities of heterocyclic compound lepalol. Most of the oils could be attributed to the ledol+palustrol or ledol+palustrol+ascaridole chemotype.

Antifungal activity of *Rh. tomentosum* EOs was evaluated by several different techniques: against *Penicillium cyclopium* Westling, *Trichoderma harzianum* Rifai and *Candida parapsilosis* using an agar diffusion method; and amperometricaly, using *Saccharomyces cerevisiae* yeast-modified electrodes.

Anti-inflammatory activity of Lithuanian marsh rosemary EOs has been revealed by subcutaneous carrageenan injection-induced hind paw oedema tests. However, antioxidant activity (tests using ABTS°⁺, DPPH° and TROLOX) and toxic properties (against brine shrimp (*Artemia sera*) larvae) of *Rh. tomentosum* EOs were summarized.

Keywords: *Rhododendron tomentosum* H., Ericaceae, essential oil composition, ledol, palustrol, ascaridole, cyclocolenones, antifungal activity, antioxidant tests, antimicrobial properties, toxicity in vivo

*Corresponding author. Email: asta.judzentiene@ftmc.lt
INTRODUCTION

Rhododendron tomentosum (Stokes) H. Harmaja (formerly mostly known as Ledum palustre Linnaeus, Ericaceae Juss.) is a perennial woody shrub (up to 1 m in height) with evergreen leaves and small white or white-pink sticky flowers grouped in racemes. The flowering period is from April to August, depending on the geographical area. The plant is called commonly as a marsh rosemary, marsh tea or marsh Labrador tea. Its names suggest (including the Lithuanian name Pelkinis gailis) that for the plant it is most appropriate to grow in marshy and swampy areas. The preferred growing habitats are peaty and acidic soils, with various sun illuminations. Wild populations of marsh rosemary are found in Northern and Central Europe, Northern Asia (China, Korea and Japan) and N. America. Only one species of the plant (ex L. palustre var. palustre) grows in Lithuania [1], mainly forming colonies in limited areas over all the territory: in marshes, pine-woods, and in the forests on the Baltic seashore.

Preparations of marsh rosemary are widely used in folk medicine and homeopathy for treatment of various sickness, externally and internally as well. A long list of traditional uses has been presented in a review article of Popescu and Kopp (2013) [2]. In Lithuanian folk medicine, decoctions, alcohol-ic extracts or crushed raw material of the plant are used for healing rheumatism, podagra, gout, different pains, to block bleeding, insect bites, eczema and other skin problems, infections, bronchitis, pertussis, asthma, cold, cough, tuberculosis, enterocolitis, etc. In ancient times, marsh rosemary leaves were used for bear preparation instead of hops.

All parts of marsh rosemary synthesize a high content of poisonous terpenoids and emit a strong characteristic smell, which attracts bees and other pollinating insects. Flavour of the plant possesses repellent properties effective against bedbugs, clothing moths and cockroaches. The strong specific smell affects the central nervous system, and may cause nausea, headache or aggressive behaviour to some people.

The most applications of Rh. tomentosum in folk medicine and pharmacological properties have been defined on the basis of the current scientific researches [3–4].

Many research works have been devoted to investigate various bioactivities, such as antibacter-
Table 1. Already scientifically improved biological properties of *Rh. tomentosum* Harmaja (ex *Ledum palustre* L.) extracts, essential oils or emitted volatiles

<table>
<thead>
<tr>
<th>Biological activity, method applied</th>
<th>Literature source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticancer <em>in vitro</em>, using mouse leukemia cells L1210</td>
<td>[5]</td>
</tr>
<tr>
<td>Anticancer <em>in vitro</em>, using human lympho-blastoid Raji cells</td>
<td>[6]</td>
</tr>
<tr>
<td>Analgesic, using model of acetic acid-induced writhing response in mice</td>
<td>[7]</td>
</tr>
<tr>
<td>Antibacterial <em>in vitro</em>, by broth dilution method, against <em>Staphylococcus aureus</em>, <em>Escherichia coli</em>, <em>Pseudomonas aeruginosa</em> and <em>Klebsiella pneumoniae</em></td>
<td>[8]</td>
</tr>
<tr>
<td>Antidiabetic <em>in vitro</em>, using C2C12 murine skeletal myoblasts and the 3T3-L1 murine preadipocyte cell lines</td>
<td>[9]</td>
</tr>
<tr>
<td>Antidiabetic <em>in vitro</em>, using Caco-2/15 cells; western blot analysis <em>in vivo</em>. Rats, oral glucose tolerance test</td>
<td>[10]</td>
</tr>
<tr>
<td>Antifungal, against <em>Aspergillus niger</em>, <em>Candida albicans</em>, <em>Microsporum canis</em>, <em>Trichophyton rubrum</em> and <em>Trichophyton mentagrophytes</em></td>
<td>[11]</td>
</tr>
<tr>
<td>Antifungal <em>in vitro</em>, by microbroth dilution method, against <em>Cryptococcus neoformans</em>, <em>Saccharomyces cerevisiae</em>, <em>Aspergillus niger</em> and <em>Candida albicans</em></td>
<td>[12]</td>
</tr>
<tr>
<td>Antifungal, using agar disc diffusion assay, against <em>Candida parapsilosis</em></td>
<td>[13]</td>
</tr>
<tr>
<td>Antifungal, using mediated amperometry at <em>Saccharomyces cerevisiae</em>-modified electrodes</td>
<td>[13]</td>
</tr>
<tr>
<td>Antifungal, by agar-diffusion method, against <em>Trichoderma harzianum</em> and <em>Penicillium cyclopium</em></td>
<td>[14, 15]</td>
</tr>
<tr>
<td>Anti-inflammatory, by model of lambda-carrageenan-induced paw edema in mice</td>
<td>[7]</td>
</tr>
<tr>
<td>Anti-inflammatory <em>in vivo</em>, using tests of carrageenan-induced edema in rats</td>
<td>[8]</td>
</tr>
<tr>
<td>Anti-inflammatory, using tests of subcutaneous carrageenan injection-induced hind paw edema in rats</td>
<td>[16]</td>
</tr>
<tr>
<td>Anti-inflammatory <em>in vitro</em>, by prostaglandin biosynthesis assay; PAF-induced exocytosis</td>
<td>[17]</td>
</tr>
<tr>
<td>Antimicrobial <em>in vitro</em>, against <em>Staphylococcus aureus</em>, <em>Streptococcus pneumoniae</em>, <em>Clostridium perfringens</em>, <em>Bacillus cereus</em>, <em>Enterobacter aerogenes</em>, <em>Klebsiella pneumoniae</em>, <em>Candida albicans</em>, <em>Mycobacterium smegmatis</em>, <em>Acinetobacter Iwoffii</em> and <em>Candida krusei</em></td>
<td>[18]</td>
</tr>
</tbody>
</table>

Fig. 1. Geographical distribution of sampling sites (in Lithuania) of *Rhododendron tomentosum* H. plants, whose EOs are already investigated
Variuos parts of the plant – all aerial parts or separated shoots, inflorescences and seeds – have been chosen for the oils preparation. Plant material was dried at room temperature (20–25°C); different plant organs were separated before drying.

**ESSENTIAL OIL PREPARATION**

Hydrodistillation (HD) was performed in a circular-Clevenger-type apparatus, according to the procedure described in the European Pharmacopoeia. In order to obtain sufficient amounts of wild rosemary EOs, HD time of 2 h was chosen [13, 31–34], and the procedure time of 4 h up to exhaustion of all oils present in the matrix [16]. Previously, it was proved that the extension of distillation time from 2 to 4 h has increased *Rh. tomentosum* oil yield without significant changes in the composition of the oils [35]. Obtained EO is as yellow-grey, greasy mass with a sweet characteristic odour.

Supercritical CO₂ extraction (SFE) of *Rh. tomentosum* herbal material was performed in a laboratory apparatus, working at 90 bar and 10°C in the extraction vessel, at 90 bar and 10°C in the first separator and at 20 bar and 15°C in the second one [16]. The extraction procedure was carried out in a semi batch mode: batch charging of vegetable material and continuous flow of solvents.

The content of EO from Lithuania marsh rosemary aerial parts varied from 0.45 to 2.01% (v/w, on a dry weight basis). The lowest contents 0.45 and 0.59% of the oils were obtained for aged (mature) shoots gathered in Rokiškis District [31], and from young shoots collected in April in Samanis forest marshes (Utena District), respectively [13, 32]. The largest quantity (2.0%) of the EO was obtained after 4 h of a hydro-distillation procedure [16]. The yields of *Rh. tomentosum* EOs varied significantly (almost 3-fold) depending on the plant vegetation stage. The oil yields changed during plant growing stages: maximum values 1.73 and 1.76% (v/w) were determined in June and July (at the end of flowering), respectively. Thereafter, the yields decreased to 1.36% (v/w) in October, at the full seeding stage [13, 32]. The quantity of 0.9% (v/w) of the EO was isolation from seeds [34]. Significant differences (from 2.8- to 4.5-fold) were found between the minimum and the maximum yields of the investigated essential oils [13, 16, 31–34].

Variability in the content of EOs could be explained also by growing conditions, temperature, sun illumination intensity and duration of isolation procedure as well.

**MAIN COMPOSITION OF RHODODENDRON TOMENTOSUM HARMAJA (EX LEDUM PALUSTRE LINN) ESSENTIAL OILS**

 Constituents with 2,6-dimethyloctane, menthane and aromadendrane skeletons are major and characteristic compounds for the EOs of marsh rosemary of the Lithuanian origin (Fig. 3).

Monoterpene hydrocarbons: *p*-cymene, myrcene and limonene, bicyclic monoterpenoid ascaridole and oxygenated sesquiterpenes: ledol, palustrol, and cyclocolorenones were determined as principal compounds in the investigated Lithuanian *Rh. tomentosum* EOs (Table 2). The structure
Table 2. Main constituents (%) of *Rh. tomentosum* Harmaja (Lithuanian origin, *ex* *Ledum palustre* L.) essential oils from already published data

<table>
<thead>
<tr>
<th>Location, Reference</th>
<th>No. in BILAS</th>
<th>Plant organ, EO content, %</th>
<th>Ledol</th>
<th>Palustrol</th>
<th>iso-Ascaridole</th>
<th>p-Cymene</th>
<th>Myrcene</th>
<th>Limonene</th>
<th>Cyclocol-orenones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juodupė, Rokiškis d. [31]</td>
<td>not indicated</td>
<td>Young and aged shoots, 0.45–2.01</td>
<td>23.9–30.8</td>
<td>35.2–42.8</td>
<td>0.1</td>
<td>tr.–0.3</td>
<td>5.7–8.6</td>
<td>not indicated</td>
<td>5.0–9.3</td>
</tr>
<tr>
<td>Šilėnai, Vilnius d. [31]</td>
<td>not indicated</td>
<td>Young and aged shoots, 0.55–1.52</td>
<td>23.63–0.5</td>
<td>31.4–36.7</td>
<td>0.2–0.3</td>
<td>0.1</td>
<td>1.2–6.1</td>
<td>3.7–11.0</td>
<td>4.0–5.3</td>
</tr>
<tr>
<td>Samanis forest, Utena d. [32]</td>
<td>68889</td>
<td>All aerial parts from April to October collected at the same day of month</td>
<td>21.0–32.3</td>
<td>26.2–37.9</td>
<td>tr.–14.2</td>
<td>0.2–5.0</td>
<td>0.4–11.4</td>
<td>below detection limits</td>
<td>2.7–6.5</td>
</tr>
<tr>
<td>Šulnys Lake, Šalčininkai d. [33]</td>
<td>68886–68888</td>
<td>All aerial parts during flowering, not indicated</td>
<td>5.2–23.4</td>
<td>1.2–31.8</td>
<td>16.7–20.5</td>
<td>6.2–20.3</td>
<td>0.1–1.0</td>
<td>0–0.9</td>
<td>0.1–2.0</td>
</tr>
<tr>
<td>Samanis forest, Utena d. [13]</td>
<td>68889</td>
<td>All aerial parts, collected every month from April to October, 0.59–1.76</td>
<td>18.0 ± 2.9–29.0 ± 5.0</td>
<td>24.6 ± 2.6–33.5 ± 4.4</td>
<td>0.1 ± 0.1–14.0 ± 2.4</td>
<td>0.2 ± 0.2–4.8 ± 0.2</td>
<td>0.4 ± 0.1–10.1 ± 1.3</td>
<td>not indicated</td>
<td>2.7 ± 0.5–6.2 ± 0.3</td>
</tr>
<tr>
<td>Rūdninkai, Šalčininkai d. [34]</td>
<td>68890</td>
<td>Seeds, 0.9 shoots, 1.5 In seed EO: 27.0, in shoot EO: 36.5</td>
<td>0.7–5.0</td>
<td>1.7–2.2</td>
<td>0.4–1.9</td>
<td>below detection limits</td>
<td>2.1–3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not indicated [16]</td>
<td>168, Herbarium in the Faculty of Pharmacy, Monastir, Tunisia</td>
<td>Aerial parts, by SFE – 1.5, by – 2.0</td>
<td>23.3–26.7</td>
<td>41.0–43.4</td>
<td>4.5–15.1*</td>
<td>0.9–1.3**</td>
<td>0.5–0.9</td>
<td>tr.–0.7</td>
<td>3.0–4.8</td>
</tr>
</tbody>
</table>

*d.* district; HD, hydrodistillation; SFE, supercritical CO₂ extraction.

* According to the authors [16], identified compound is ascaridole.

** According to the authors [16], identified constituent is o-cymene.

Fig. 2. Main carbon skeletons of *Rhododendron tomentosum* H. (Lithuanian origin) essential oil constituents.

Of main constituents is presented in Fig. 3. Most of the oils could be attributed to the ledol+palustrol or ledol+palustrol+ascaridole chemotype. It should be mentioned that the ledol+palustrol chemotype is common for the EOs of *Rh. tomentosum* plants of the European and Asian origin. Ascaridole (organic peroxide) has been identified as a predominant compound in the marsh rosemary growing in some countries, such as Finland and Sweden [24, 53]. Monoterpene myrcene has been determined among main constituents or even the first major one in *Rh. tomentosum* EOs from other world countries (Sweden, Finland, Estonia, Russia (Tomsk region) and China) [25, 35–37, 54]. Marsh rosemary oils with the predominant compound p-cymene were evaluated also in some countries (Finland, North East China, etc.) [35, 38, 59]. Monoterpene limonene is quite rare as the major constituent in the EOs of *Rh. tomentosum*. 
Limonene, p-cymene and myrcene were determined in appreciable quantities in the oils of the plants collected in the Southern regions of Tomsk, Transbaikalia and Amur Province, and also from the Southern part of the Island of Sakhalin [40]. Cyclocolorenone derivatives were identified as the dominating constituents in marsh rosemary plants of the Russian origin (Leningrad Region) [41]. Some investigated Rh. tomentosum EOs of the Lithuanian origin were characterized by appreciable amounts of the specific constituents, furyl containing compounds, such as lepaline (3-(4-methyl)-1,4-pentadienyl) furan), lepalone (5-(3-furyl)-2-methyl-1-penten-3-one), lepalol (5-(3-furyl)-2-methyl-1-penten-3-ol) and 2-methyl-5-(3-furyl)-3-penten-2-ol [13, 32, 34]. Quantities of the heterocyclic compound lepalol reached up to 7.9 ± 0.3% of the total oil content in some studies [13, 32].

**BIOLOGICAL PROPERTIES OF MARSH ROSEMARY (RHODODENDRON TOMENTOSUM HARMAJA (EX LEDUM PALUSTRE LINN), LITHUANIAN ORIGIN)**

**ANTIFUNGAL ACTIVITY**

Antifungal activity of Rh. tomentosum EOs was evaluated by several different techniques: against *Penicillium cyclopium* Westling, *Trichoderma harzianum* Rifai, using an agar diffusion method [14, 15]; against pathogenic yeast *Candida parapsilosis* in agar disc diffusion assay [13]; and amperometrically, using *Saccharomyces cerevisiae* yeast-modified electrodes [13].

**Rh. tomentosum** EOs activity against *Trichoderma harzianum* and *Penicillium cyclopium*

A strong antifungal activity of Rh. tomentosum EOs was evaluated against *Trichoderma harzianum* Rifai and also *Penicillium cyclopium*. Growth of the mitosporic fungus *T. harzianum* was inhibited by all investigated Rh. tomentosum essential oils, obtained from the plants (from Utena District) of various vegetative stages and different organs (shoots and flowers) [14, 15]. The EOs suppressed totally the development of this fungus after seven days.

A little weaker (comparing with *T. harzianum*) antifungal activity was observed against *P. cyclopium* using flower marsh rosemary oils. The oil influenced fungus growth only during the first three days, while its influence decreased after seven days. Only two shoot oils (gathered in July and August, Fig. 4.3, 4.4) containing, despite principal compounds ledol and palustrol, appreciable amounts of iso-ascaridole (14.0 ± 2.4 and 12.7 ± 2.0%), and p-cymene (4.0 ± 0.4 and 4.8 ± 0.2%) completely suppressed growth of *P. cyclopium*.

The study has confirmed that Rh. tomentosum EOs can find practical application as a growth inhibitor of some micromycetes [14].

**Antifungal activity of Rh. tomentosum EOs against Candida parapsilosis**

An agar disc diffusion assay against the pathogenic yeast *Candida parapsilosis* (CBS 883C) was evaluated; and the data from this experiment revealed the potential antifungal activity of marsh rosemary EOs [13]. The filter paper discs were impregnated with 10 μL of diluted EO and nystatin (an agent used to treat *Candida* infections) as a positive control reagent. The inoculated Petri plates were incubated at 30°C for 48 h, the inhibition zone around an EO-impregnated paper disc was found to be three-fold larger compared to that around a commercial nystatin-impregnated paper disc. However, the density of the *C. parapsilosis* lawn in a plate containing EO was lower than in the plate with nystatin, indicating the suppressing effect of EO vapours on the pathogenic fungi growth [13].
Antifungal activity: Rh. tomentosum EOs impact on yeast (Saccharomyces cerevisiae) membranes

Antifungal activity of EOs was investigated by mediated amperometry at yeast Saccharomyces cerevisiae-modified electrodes [13]. The effect of the essential oil on yeast membrane permeability was monitored by comparing the current responses to lactic acid at yeast-modified electrodes treated with vapours of EO with those obtained at electrodes without such treatment. Employing the responses of yeast-modified electrodes to L-lactic acid, the effect of vapours of Rh. tomentosum EO on the permeability of yeast S. cerevisiae cell walls was tested [13]. The data from the above study showed that the subjection of yeast cells to vapours of EO resulted in the 3 to 4-fold increase of electrode responses due to the disruption of yeast cell membranes.

ANTIOXIDANT ACTIVITY OF RH. TOMENTOSUM EOS

The ABTS•⁺ (2,2’-amino-bis(ethylbenzothiazoline-6-sulfonic acid) diammonium salt) and DPPH• (2,2-diphenyl-1-picrylhydrazyl) assays are commonly used to evaluate the ability of present antioxidants in the matrix to scavenge free radicals.

A variation of antioxidant activities was evaluated among Rh. tomentosum EOs samples from Samanis marsh (Utena District) depending on the plant vegetation stage [13]. The highest antioxidant activity was exhibited by young shoot EO (herbal material collected in June). It was concluded in the research that the older the plant, the lower the ability of EO is to scavenge free radicals (for shoot oils of the plants collected in September and October) [13].

ANTI-INFLAMMATORY ACTIVITY OF RH. TOMENTOSUM EOS BY SUBCUTANEous CARRAGEENAN INJECTION-INDUCED HIND PAW OEDEMA TESTS

The anti-inflammatory activity of two plant extracts – fraction obtained by supercritical fluid extraction (SFE) and EO extracted by hydrodistillation (HD) from the aerial parts of Rh. Tomentosum – has been reporteded [16]. The extracts containing as the main compound palustrol
(41.0–43.4%), ledol (23.3–26.7%) and ascaridole (4.5–15.1%) showed an anti-inflammatory activity. The tests were evaluated by the subcutaneous carrageenan injection-induced hind paw oedema. The treated animals received essential oil (SFE and HD), the reference group received ketoprofen or piroxicam and the control group received NaCl 0.9% [16].

The results of the above study showed that the EOs enhanced a significant inhibition of oedema 50–73% for HD oil and 52–80% for SFE oil. These results were similar to those obtained with piroxicam (70%) and ketoprofen (55%). Rh. tomentosum essential oils extracted both by HD and SFE showed a significant anti-inflammatory activity as compared with non-steroidal anti-inflammatory drugs [16].

**TESTS OF TOXIC ACTIVITY OF RH. TOMENTOSUM EOS IN VIVO**

A toxicity test of the eight EOs (isolated from shoots and inflorescences; plant material collected in Samanis marsh (Utena District)) showed that the lethality LC₉₀ and LC₉₅ of brine shrimp (Artemia sera) larvae was 11.23–20.50 and 34.00–76.07 (µg/mL), respectively [13]. In general, the data from the above study revealed that all Rh. tomentosum EOs were notably toxic. Among them, EO obtained from shoots gathered in September (during the seed ripening stage) and containing appreciable amounts of palustrol (26.0 ± 2.5%), ledol (21.5 ± 4.0%) and ascaridole (7.0 ± 2.4%) appeared the most toxic. In contrary, inflorescence oil including almost the same quantities of palustrol (30.0 ± 1.6%) and ledol (23.3 ± 2.3%), but 10.1 ± 1.3% of myrcene and insignificant amounts of ascaridole isomers was evaluated as less toxic [13].

Received 14 August 2020
Accepted 21 September 2020

**References**

Asta Judžentienė

PELKINIO GAILIO (RHODODENDRON TOMENTOSUM HARMAJA (EX LEDUM PALUSTRE LINN)), AUGANČIO LIETUVOJE, ETERINIAI ALIEJAI IR JŲ SAVYBĖS

Santrauka

Straipsnis apibendrina Lietuvoje augančio pelkinio galio (Rhododendron tomentosum Harmaja (ex Ledum palustre Linn)) eterinų aliejų sudėties ir jų biologinės savybės. Aliejuose pagrindiniais junginiais nustatyti šie monoterpenai: p-cimenas, mircenas ir limonenas, biciklinis monoterpenoidas askaridolis ir oksiduoti seskviterpenai: ledolis, palustrolis bei ciklokoloreno- nai. Didžioji dalis ištirtų lietuviškų gailių eterinų aliejų gali būti priskirti ledolis + palustrolis ar ledolis + palustrolis + askaridolis chemotipams.

Pateikti duomenys susiję su lietuviško pelkinio galio antifungicidiniu aktyvumu prieš Trichoderma harzianum, Penicillium cyclopium ir Candida parapsilosis, panaudojant agaro diskų difuzijos metodą, taip pat amperometriškai, naudojant Saccharomyces cerevisiae mielėmis modifikuotus elektrodus.

Priešuždegiminių lietuviško pelkinio galio eterinio aliejų savybės buvo ištirtos su laboratorinėmis žiurkėmis, mokslinėmis, taip pat amperometriškai, naudojant Saccharomyces cerevisiae mielėmis modifikuotus elektrodus.

Asta Judžentienė